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VOL. II.

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NEW YORK.

SUBJECTS AND AUTHORS.

MINING INDUSTRY OF THE UNITED STATES,

Including Gold, Silver, Copper, Lead, Zinc, Iron, Coal, Petroleum, &c., showing the Localities, Richness of Ores, Methods of Mining, Smelting, and applying the different Minerals to practical uses, with their values, &c., &c.

FUR TRADE, various kinds and values of Furs.

HAT MANUFACTURE.

By JAMES T. HODGE, *Geologist,*

Of the late Pennsylvania, and other Geological Surveys; Contributor to Appleton's "New American Cyclopædia" on the same subjects.

IMPROVEMENTS IN THE MEANS OF TRAVEL AND TRANSPORTATION,

Including Common Roads, Turnpikes, M'Adam, Plank and Railroads, River and Ocean Steamers; giving a history of their origin, progress, and influence upon the growth of the country, their extent, construction, cost, &c.

MANUFACTURES

Of Cotton, Woollen, Paper, Leather, Boots and Shoes, Fire-Arms, Cutlery, Carriages and Coaches, Clocks and Watches, Electro-plated Ware, Pins, Refined Sugars, Silk, Fire-Proof Safes, Bank Locks, Glass, India-Rubber, Sewing Machines, Musical Instruments, showing the various improvements made by machinery and other means of manufacture, the extent of operations and value of productions, &c., &c.

BUILDING, BUILDING MATERIALS, FISHING INTERESTS, AND FLOUR MILLS.

By THOMAS P. KETTELL,

For ten years Commercial Editor of the "New York Herald;" for many years Editor of Hunt's "Merchants' Magazine;" late Editor and Conductor of the "Democratic Review;" and New York Correspondent of the "Washington Union," (organ of the government,) for twelve years, over the signature of "Prentice."

STEAM ENGINE,

Its invention, various improvements, manufacture, and uses, with reference to its influence upon the industry of the country in its application to manufactures.

By J. C. MERRIAM,

Editor and Proprietor of the "American Engineer."

The Publisher, being determined to insure the greatest possible accuracy for this work, submitted it for correction, after it had been electrotyped, to Mr. F. A. Teall, who has had the final revision of the manuscripts and proofs of the later volumes of Appleton's "New American Cyclopædia." Mr. Teall's long experience as a critical proof-reader, with the use of a large collection of the best authorities, enabled him to correct many errors and discrepancies, necessarily incidental to so extensive an undertaking, which had escaped previous revisers. While admitting the impossibility of securing absolute correctness in such a mass of facts and statistics, the Publisher confidently submits the work as a trustworthy and unique record of the wonderful progress of our country from its infancy to the present time.

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CENSUS, 1860.

THE FOLLOWING TABLE GIVES THE TOTAL POPULATION OF THE UNITED STATES ACCORDING TO THE CENSUS OF 1860, DISTINGUISHING FREE FROM SLAVE, SHOWING ALSO THE NUMBER OF STATES, THE RANK OF EACH STATE ACCORDING TO ITS POPULATION AND THE NUMBER OF REPRESENTATIVES TO WHICH IT IS ENTITLED IN CONGRESS, THE TAXABLE VALUATION ACCORDING TO THE LATEST RETURNS, AND THE NUMBER OF MILITIA IN EACH STATE.

States.	Total free population.	Slaves.	Representation in Congress.	Rank as per population.	Valuation.	Militia.
Maine	619,958	..	5	22	$162,472,914	73,552
New Hampshire	326,072	..	3	27	103,804,826	33,538
Vermont	315,877	..	3	28	86,775,213	23,015
Massachusetts	1,231,494	..	10	7	597,936,995	161,192
Rhode Island	174,621	..	1	29	111,175,174	17,826
Connecticut	460,670	..	4	24	211,187,683	54,630
New York	3,851,563	..	30	1	1,404,907,679	418,846
New Jersey	676,084	..	5	20	281,333,849	81,984
Pennsylvania	2,924,501	..	23	2	568,770,284	350,000
Ohio	2,377,917	..	19	3	840,800,031	279,809
Michigan	754,291	..	6	16	120,362,474	109,570
Illinois	1,687,404	..	13	4	407,477,367	257,420
Indiana	1,370,802	..	11	6	818,204,964	58,978
Wisconsin	768,485	..	6	15	152,537,700	71,321
Iowa	682,002	..	5	19	197,223,550	110,000
Minnesota	172,793	..	1	30	781,100	24,990
Kansas	143,642	..	1	32	679,240	21,000
California	884,770	..	3	26	131,306,269	207,730
Oregon	52,566	..	1	36	1,981,101	9,000
Maryland	646,183	85,382	6	17	253,477,588	46,864
Delaware	110,548	1,805	1	33	30,466,924	9,220
Virginia	1,097,373	495,826	11	5	730,817,653	142,155
District of Columbia	72,023	3,234	..	35	20,271,000	8,201
North Carolina	679,965	328,377	7	12	271,781,101	79,448
South Carolina	308,186	407,185	4	18	214,101,202	36,072
Georgia	615,386	467,461	7	11	337,969,471	78,699
Florida	81,885	63,809	1	31	22,216,915	12,122
Alabama	520,444	435,473	6	13	201,100,100	76,662
Louisiana	354,245	312,186	4	21	378,911,905	91,324
Mississippi	407,551	479,607	5	14	161,747,536	36,084
Missouri	1,085,590	115,619	9	8	274,965,164	118,047
Kentucky	933,707	225,902	8	9	334,770,701	88,979
Tennessee	859,528	287,112	8	10	266,249,884	71,252
Arkansas	331,710	109,065	3	25	53,255,711	47,450
Texas	415,999	184,956	4	23	138,722,638	19,766
Nebraska	28,893	..	..	38	..	..
New Mexico	82,060	..	..	34	..	..
Utah	50,000	..	..	37	..	..
Washington	11,624	..	..	39	..	..
Dakotah	4,839	..	..	40	..	..
Total	27,673,271	4,002,996	234	..	$9,812,404,850	3,303,811

It will be observed that the figures for the total population do not quite agree with those in vol. i., p. 160, for the year 1860. This arises from the fact that after that table was printed a revision took place in the official tables. The column of valuations, it will be borne in mind, is that of the several States, each for its own taxation purposes, and each on its own peculiar basis. The figures do not therefore give relative values between the States.

PRINCIPAL CITIES OF THE UNITED STATES, INCLUDING ONLY THOSE WITH A POPULATION OF OVER 50,000 IN 1860.

Name.	1790.	1800.	1810.	1820.	1830.	1840.	1850.	1860.
New York	33,131	60,489	96,373	123,706	203,007	312,710	515,547	821,113
Brooklyn	..	8,298	4,402	7,175	12,042	36,233	96,838	278,325
Williamsburg	..	..	..	..	1,620	5,080	30,780	
Boston	18,038	24,027	32,250	43,298	61,372	93,383	136,881	177,902
Baltimore	13,503	26,614	46,555	62,738	80,625	102,313	169,054	212,412
Philadelphia	42,520	70,287	96,664	108,116	167,188	258,037	408,762	568,034
Cincinnati	..	750	2,540	9,644	24,831	46,338	115,436	158,851
Chicago	..	..	..	..	..	4,479	29,963	109,429
Louisville	..	..	1,357	4,012	10,352	21,210	43,194	76,226
Newark	..	..	..	6,507	10,953	17,290	38,894	72,055
New Orleans	..	..	17,242	27,196	46,310	102,193	116,375	170,766
St. Louis	..	..	..	4,893	5,852	16,469	77,860	160,377
Buffalo	..	..	1,508	2,095	8,653	18,213	42,261	81,541
Washington	..	3,210	8,208	13,247	18,827	23,364	41,000	61,400

SLAVE POPULATION OF THE UNITED STATES.

WITH THE RATIO OF SLAVES TO THE WHOLE POPULATION IN THE PRESENT SLAVE STATES, BY EACH DECENNIAL CENSUS BY THE FEDERAL GOVERNMENT SINCE ITS FORMATION.

	1790.	Ratio to pop.	1800.	Ratio to pop.	1810.	Ratio to pop.	1820.	Ratio to pop.	1830.	Ratio to pop.	1840.	Ratio to pop.	1850.	Ratio to pop.	1860.	Ratio to pop.
Maine	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..
New Hampshire	158	..	8	..	..	..	..	..	3	..	1	..	..	..	..	..
Vermont	17	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Massachusetts	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rhode Island	952	..	381	..	108	..	48	..	17	..	5	..	..	..	..	..
Connecticut	2,759	..	951	..	310	..	97	..	25	..	17	..	..	..	..	..
New York	21,324	..	20,343	..	15,017	..	10,088	..	75	..	4	..	..	..	..	..
New Jersey	11,423	..	12,422	..	10,851	..	7,557	..	2,254	..	674	..	119	..	..	..
Pennsylvania	3,737	..	1,706	..	795	..	211	..	403	..	64	..	..	..	..	..
	40,370		35,811		27,081		18,001		2,779		765		119		..	
Delaware	8,887	15.0	6,153	9.5	4,177	5.7	4,509	6.2	3,292	4.2	2,605	3.3	2,289	2.5	1,805	1.6
Maryland	103,036	32.2	105,635	30.9	111,502	29.3	107,398	26.3	102,994	23.0	89,737	19.0	89,800	15.5	85,382	12.7
District of Columbia	..	..	3,244	..	5,395	..	6,377	..	6,119	..	4,694	..	3,687	..	3,234	..
Virginia	293,427	39.2	345,796	39.2	392,518	40.2	425,153	39.9	469,757	38.7	448,987	36.2	473,026	33.2	495,826	30.8
North Carolina	100,572	25.5	133,296	27.8	168,824	30.3	205,017	32.0	245,601	33.2	245,817	32.6	288,412	33.2	328,377	33.9
South Carolina	107,014	43.0	146,151	42.2	196,365	47.3	258,475	51.4	315,401	54.2	327,038	55.0	384,925	57.6	407,185	57.2
Georgia	29,264	35.4	59,504	36.6	105,218	41.6	149,656	43.8	217,531	42.0	280,944	40.6	362,996	42.1	467,461	43.7
Florida	..	..	..	..	..	..	..	..	15,011	44.6	25,717	47.2	39,341	44.9	63,809	44.0
Alabama	..	..	..	..	..	..	47,439	32.7	117,549	37.9	253,532	42.9	342,894	42.4	435,473	45.1
Mississippi	..	..	3,489	39.4	17,088	42.3	32,814	43.4	65,659	48.0	195,211	51.9	300,419	51.0	479,607	55.1
Louisiana	..	..	..	..	34,660	45.2	69,064	45.0	109,588	50.8	168,452	47.8	230,807	47.2	312,186	46.9
Texas	..	..	..	..	..	..	..	..	..	..	..	..	58,346	27.3	184,956	30.0
Arkansas	..	..	..	..	..	..	1,617	11.3	4,576	15.0	19,935	20.4	46,983	22.4	109,065	25.5
Tennessee	3,417	9.5	13,584	12.8	44,535	17.0	80,107	18.9	141,603	20.7	183,059	22.0	249,519	23.8	287,112	24.8
Kentucky	11,830	16.1	40,343	18.2	80,561	19.8	126,732	22.4	165,213	24.0	182,258	23.3	221,768	21.4	225,902	19.5
Missouri	..	..	..	..	3,011	14.4	10,222	15.3	25,091	17.8	58,240	15.1	89,289	12.8	115,619	9.8
Indiana	..	..	135	..	237	..	190	..	3	..	3	..	..	..	..	..
Ohio	..	..	..	..	..	..	..	..	6	..	3	..	..	..	..	..
Illinois	..	..	..	..	168	..	917	..	747	..	331	..	..	..	..	..
Wisconsin	..	..	..	..	..	..	..	..	..	..	11	..	..	..	..	..
Iowa	..	..	..	..	..	..	..	..	..	..	16	..	..	..	..	..
Michigan	..	..	..	..	24	..	..	..	32	..	..	..	..	..	..	..
Total	658,527		857,230		1,164,283		1,525,667		2,096,264		2,486,590		3,179,470		..	
General total	697,897		893,041		1,191,364		1,543,668		2,099,043		2,487,355		3,179,589		4,002,996	

MINING INDUSTRY OF THE UNITED STATES.

INTRODUCTORY REMARKS.

THE mineral wealth of the American colonies does not appear to have been an object of much interest to the early settlers. Congregated near the coast, they were little likely to become acquainted with many of the mineral localities, most of which are in the interior, in regions long occupied by the Indian tribes. The settlers, moreover, probably possessed little knowledge of mining, and certainly lacked capital which they could appropriate in this direction. Some discoveries, however, were made by them very soon after their settlement, the earliest of which were on the James river, in Virginia. Beverly, in his "History of the Present State of Virginia," published in London in 1705, makes mention of iron works which were commenced on Falling Creek, and of glass-houses which were about to be constructed at Jamestown just previous to the great massacre by the Indians, in 1622. This undertaking at Falling Creek is referred to by other historians, as by Stith, in his "History of Virginia" (1753), p. 279. A Captain Nathaniel Butler, it appears, presented to the king, in 1623, a very disparaging account of the condition of the colony, mentioning, among other matters, that "the Iron Works were utterly wasted, and the People dead; the Glass Furnaces at a stand, and in small Hopes of proceeding." The committee of the company, in their reply to this, affirm that "great Sums had been expended, and infinite Care and Diligence bestowed by the Officers and Company for setting forward various Commodities and Manufactures; as Iron Works," etc., etc. Salmon, in his "Modern History" (1746), vol. iii, pp. 439 and 468, refers to the statement of Beverly, mentioning that "an iron work was set up on Falling Creek, in James River, where they found the iron ore good, and had near brought that work to perfection. The iron proved reasonably good; but before they got into the body of the mine, the people were cut off in that fatal massacre (of March, 1622), and the project has never been set on foot since, until of late; but it has not had its full trial." This author also refers to the representations of the Board of Trade to the House of Commons, in 1732, as containing notices of the iron works in operation in New England. From various reports of the governor of Massachusetts Bay and other officials of this colony, there appear to have been, in 1731, as many as six furnaces and nineteen forges for making iron in New England, as also a slitting mill and nail factory connected with it.

The first blast furnace in the colonies appears to have been built in 1702, by Lambert Despard, at the outlet of Mattakeeset pond, in Plymouth County, Massachusetts, and a number more were afterward set in operation to work the bog ores of that district. Their operations are described in the "Collections of the Massachusetts Historical Society" for 1804, by James Thacher, M. D., who was himself engaged in the manufacture. In Rhode Island and Providence Plantations, the same kinds of ore were found and worked at about the same period. Alexander gives the year 1715 as the epoch of blast furnaces in Maryland, Virginia, and Pennsylvania. These enterprises were regarded with great disfavor in the mother country. In 1719 an act was brought forward in the House of Lords, forbidding the erection of rolling or slitting mills in the American colonies, and in 1750 this was made a law.

In Connecticut, Governor Winthrop was much interested in investigating the character of the minerals about Haddam and Middletown. In 1651 he obtained a license giving him almost unlimited privileges for working any mines of "lead, copper, or tin, or any minerals; as antimony, vitriol, black lead, alum, salt, salt springs, or any other the like, * * * to enjoy forever said mines, with the lands, woods, timber, and water within two or three miles of said mines." And in 1661, another special grant

was made to him of any mines he might discover in the neighborhood of Middletown. It does not appear, however, that he derived any special advantage from these privileges, although he used to make frequent excursions to the different localities of minerals, especially to the Governor's Ring, a mountain in the north-west corner of East Haddam, and spend three weeks at a time there with his servant, engaged, as told by Governor Trumbull to President Styles, and recorded in his diary, in "roasting ores, assaying metals, and casting gold rings." John Winthrop, F.R.S., grandson of Governor Winthrop, was evidently well acquainted with many localities of different ores in Connecticut, and sent to the Royal Society a considerable collection of specimens he had made. It is supposed that among them Hatchett found the mineral columbite, and detected the new metal which he named columbium. At Middletown, an argentiferous lead mine was worked, it is supposed, at this period, by the Winthrops, and the men employed were evidently skilful miners. When the mine was reopened in 1852, shafts were found well timbered and in good preservation, that had been sunk to the depth of 120 feet, and, with the other workings, amounted in all to 1,500 feet of excavation. The oldest American charter for a mining company was granted in 1709, for working the copper ores at Simsbury, Connecticut. Operations were carried on here for a number of years, the ore raised being shipped to England, and a similar mining enterprise was undertaken in 1719, at Belleville, in New Jersey, about six miles from Jersey City. The products of the so-called Schuyler mine at this place amounted, before the year 1731, to 1,386 tons of ore, all of which were shipped to England. At this period (1732) the Gap mine, in Lancaster county, Pennsylvania, was first opened and worked for copper, and about the middle of the century various other copper mines were opened in New Jersey; also, the lead mine at Southampton, Mass., and the cobalt mine at Chatham, Conn. In 1754 a lead mine was successfully worked in Wythe county, in south-western Virginia, and this is still productive. It is probable that, by reason of the higher value of copper at that period, and the lower price paid for labor than at present, some of the copper mines may have proved profitable to work, though it is certain this has not been the case with them of late years. The existence of copper in the region about Lake Superior was known, from the reports of the Jesuit missionaries, in 1660, and one or two unsuccessful attempts were made to work it during the last century by parties of Englishmen. The lead mines of the upper Mississippi, discovered by Le Sueur in his exploring voyage up the river in 1700 and 1701, were first worked by Dubuque, a French miner, in 1788, upon the tract of land now occupied by the city in Iowa bearing his name.

Such, in general, was the extent to which this branch of industry had been carried up to the close of the last century. The only coal mines worked were some on the James river, twelve miles above Richmond, and the capacity of these for adding to the wealth of the country was not by any means appreciated. The gold mines were entirely unknown, and the dependence of the country upon Great Britain for the supply of iron had so checked the development of this branch of manufacture, that comparatively nothing was known of our own resources in the mines of this metal. The most important establishments for its manufacture were small blast furnaces, working bog ores, and the bloomaries of New York and New Jersey, making bar iron direct from the rich magnetic ores.

The progress of the United States in these branches will be traced in the succeeding chapters, one of which will be devoted to each of the principal metals.

CHAPTER I.

IRON.

The early history of the iron manufacture in the American colonies has been noticed in the introductory remarks which precede this chapter. Since the year 1750 the restrictions imposed upon the business by the mother country had limited the operations to the production of pig iron and castings, and a few blast furnaces were employed in New England, and the middle Atlantic states. A considerable portion of the pig iron was exported to Great Britain, where it was admitted free of duty, and articles of wrought iron and steel were returned from that country. In 1771 the shipment of pig iron from the colonies amounted to 7,525 tons. By the sudden cessation of commercial relations

on the breaking out of the war, the country was thrown upon its own resources, but was ill prepared to meet the new and extraordinary demands for iron. The skill, experience, and capital for this business were all alike wanting, and even the casting of cannon was an undertaking that few of the furnace masters were prepared to venture upon. The bog ores found in Plymouth county, Mass., together with supplies from New Jersey, sustained ten furnaces; and in Bridgewater, cannon were successfully cast and bored by Hon. Hugh Orr, for the supply of the army. They were also made at Westville, Conn., by Mr. Elijah Bachus, who welded together bars of iron for the purpose. The Continental Congress, also, was forced to establish and carry on works for furnishing iron and steel, and in the northern part of New Jersey, the highlands of New York, and the valley of the Housatonic in Connecticut, they found abundance of rich ores, and forests of the best wood for the charcoal required in the manufacture. At their armory at Carlisle, Pa., the first trials of anthracite for manufacturing purposes were made in 1775. But the condition of the country was little favorable for the development of this branch of industry, and after the war, without capital, a currency, or facilities of transportation, the iron business long continued of little more than local importance. The chief supplies were again furnished from the iron works of Great Britain, the establishment of which had in great part been owing to the restrictions placed upon the development of our own resources; and while that country continued to protect their own interest by prohibitory duties that for a long period excluded all foreign competition, the iron interest of the United States languished under a policy that fostered rather the carrying trade between the two countries than the building up of highly important manufactories, and the establishment around them of permanent agricultural settlements through the home market they should secure. Hence it was that the manufacture in Great Britain was rapidly accelerated, improved by new inventions, strengthened by accumulated capital, and sustained by the use of mineral coal for fuel, almost a century before we had learned in the discouraging condition of the art, that this cheap fuel, mines of which were worked near Richmond in Virginia, before 1790, could be advantageously employed in the manufacture. The natural advantages possessed by Great Britain powerfully co-operated with her wise legislation; and as her rich deposits of iron ore and coal were developed in close juxtaposition, and in localities not far removed from the coast, the iron interest became so firmly established that no nation accessible to her ships could successfully engage in the same pursuit, until, by following the example set by Great Britain, its own mines and resources might be in like manner developed. Thus encouraged and supported, the iron interest of Great Britain has prospered at the expense of that of all other nations, till her annual production amounts to more than one-half of the seven millions or eight millions of tons produced throughout the world; and the products of her mines and furnaces have, until quite recently, been better known, even in the extreme western states, where the cost of "Scotch pig iron" has been more than doubled by the transportation, than has that of the rich ores of these very states. And thus it is the annual production of the United States scarcely yet amounts to 1,000,000 tons, notwithstanding the abundance and richness of her mines, both of iron ores and of coal, and the immense demands of iron for her own consumption. So great are the advantages she possesses in the quality of these essential materials in the production of iron, that according to the statement of an able writer upon this subject, who is himself largely engaged in the manufacture, less than half the quantity of raw materials is required in this country to the ton of iron, than is required in Great Britain, "thus economizing labor to an enormous extent. In point of fact, the materials for making a ton of iron can be laid down in the United States at the furnace with less expenditure of human labor than in any part of the known world, with the possible exception of Scotland." ("On the Statistics and Geography of the Production of Iron," by Abram S. Hewitt, N. Y., 1856, p. 20). The tables presented by this writer, of the annual production, show striking vicissitudes in the trade, which is to be accounted for chiefly by the fluctuations in prices in the English market depressing or encouraging our own manufacture, and by the frequent changes in our tariff.

"In 1810 the production of iron, entirely charcoal, was 54,000 tons. In 1820, in consequence of the commercial ruin which swept over the country just before, the busi-

ness was in a state of comparative ruin, and not over 20,000 tons were produced.

In 1828 the product was	130,000	tons.		
" 1829 " "	142,000	"		
" 1830 " "	165,000	"		
" 1831 " "	191,000	"		
" 1832 " "	200,000	"		
" 1840 " "	315,000	"		

In 1842 it fell to less than 230,000 tons, the result of the remission of duties under the compromise tariff. In 1846 Secretary Walker estimated it to be 765,000 tons, the result of the combined action of the high tariff of 1842 and the high prices in England, caused by the new demand for railways. In 1847 and 1848 it reached 800,000 tons. In 1849 it fell to 650,000 tons. In 1850, by the census returns it was reduced to 564,755 tons; and it continued to fall off until the first of January, 1853, when the whole product did not exceed 500,000 tons; still leaving it, even at the lowest point, second only to Great Britain. The make then began to increase, so that in 1855 it had reached at least 1,000,000 of tons. This estimate is not confirmed in the tables prepared by the committee of the Association of Iron Manufacturers for 1856, which will be presented in more detail in the course of this chapter. Not reckoning the bar and blooms made direct from the ore, which in 1856 is given as 28,633 tons, the production of pig metal in 1854 was 724,833 tons; in 1855, 728,973 tons; and in 1856, 812,917 tons. The annual production at the present time probably falls short of this amount.

Until the year 1840, charcoal had been the only fuel used in the manufacture of iron; and while it produced a metal far superior in quality to that made with coke, the great demands of the trade were for cheap irons, and the market was chiefly supplied with these from Great Britain. The introduction of anthracite for smelting iron ores in 1840 marked a new era in the manufacture, though its influence was not decidedly felt for several years afterward.

MATERIALS EMPLOYED IN THE MANUFACTURE.

Before attempting to exhibit the resources of the United States for making iron, and the methods of conducting the manufacture, it is well to give some account of the materials employed, and explain the conditions upon which this manufacture depends. Three elements are essential in the great branch of the business—that of producing pig iron, viz: ores, fuel to reduce them, and a suitable flux to aid the process by melting with and removing the earthy impurities of the ore in a freely flowing, glassy cinder. The flux is usually limestone, and by a wise provision, evidently in view of the uses to which this would be applied, limestone is almost universally found conveniently near to iron ores; so also are stores of fuel commensurate with the abundance of the ores.

The principal ores are hematites, magnetic and specular ores, the red oxides of the secondary rocks, and the carbonates. Probably more than three-quarters of the iron made in the United States is from the first three varieties named, and a much larger proportion of the English iron is from the last—from the magnetic and specular ores none. Hematites, wherever known, are favorite ores. They are met with in great irregular-shaped deposits (apparently derived from other forms in which the iron was distributed), intermixed with ochres, clays, and sands, sometimes in scattered lumps and blocks, and sometimes in massive ledges; they also occur in beds interstratified among the mica slates. Although the deposits are regarded as of limited capacity, they are often worked to the depth of more than 100 feet; in one instance in Berks county, Penn., to 165 feet; and when abandoned, as they sometimes are, it is questionable whether this is not rather owing to the increased expenses incurred in continuing the enormous excavations at such depths, than from failure of the ore. Mines of hematite have proved the most valuable mines in the United States. At Salisbury, in Connecticut, they have been worked almost uninterruptedly for more than 100 years, supplying the means for supporting an active industry in the country around, and enriching generation after generation of proprietors. The great group of mines at Chestnut Hill, in Columbia county, Penn., and others in Berks and Lehigh counties in the same state, are of similar character.

The ore is a hydrated peroxide of iron, consisting of from 72 to 85 per cent. of peroxide of iron (which corresponds to about 50 to 60 per cent. of iron), and from 10 to 14 per cent. of water. Silica and alumina, phosphoric acid, and peroxide of manganese are one or more present in very small quantities; but the impurities are rarely such as to interfere with the production of very excellent iron, either for foundry or forge purposes—that is, for castings or bar iron. It is

easily and cheaply mined, and works easily in the blast furnace. On account of its deficiency in silica it is necessary to use a limestone containing this ingredient, that the elements of a glassy cinder may be provided, which is the first requisite in smelting iron; or the same end may be more advantageously attained by adding a portion of magnetic ore, which is almost always mixed with silica in the form of quartz; and these two ores are consequently very generally worked together—the hematites making two-thirds or three-quarters of the charge, and the magnetic ores the remainder.

Magnetic ore is the richest possible combination of iron, the proportion of which cannot exceed 72.4 per cent., combined with 27.6 per cent of oxygen. It is a heavy, black ore, compact or in coarse crystalline grains, and commonly mixed with quartz and other minerals. It affects the magnetic needle, and pieces of it often support small bits of iron, as nails. Such ore is the loadstone. It is obtained of various qualities; some sorts work with great difficulty in the blast furnace, and others are more easily managed and make excellent iron for any use; but all do better mixed with hematite. The magnetic ores have been largely employed in the ancient processes of making malleable iron direct from the ore in the open forge, the Catalan forge, etc., and at the present time they are so used in the bloomary fires. They are found in inexhaustible beds of all dimensions lying among the micaceous slates and gneiss rocks. These beds are sometimes so extensive that they appear to make up the greater part of the mountains in which they lie, and in common language the mountains are said to be all ore.

Specular ore, or specular iron, is so named from the shining, mirror-like plates in which it is often found. The common ore is sometimes red, steel gray, or iron black, and all these varieties are distinguished by the bright red color of the powder of the ore, which is that of peroxide of iron. Magnetic ore gives a black powder, which is that of a less oxidized combination. The specular ore thus contains less iron and more oxygen than the magnetic; the proportions of its ingredients are 70 parts in 100 of iron, and 30 of oxygen. Though the difference seems slight, the qualities of the two ores are quite distinct. The peroxide makes iron fast, but some sorts of it produce an inferior quality of iron to that from the hematite and magnetic ores, and better adapted for castings than for converting into malleable iron. The pure, rich ores, however, are many of them unsurpassed. It is found in beds of all dimensions, and though in the eastern part of the United States they prove of limited extent, those of Missouri and Lake Superior are inexhaustible. Magnetic and specular ores are associated together in the same district, and sometimes are accompanied by hematite beds; and it is also the case, that iron districts are characterized by the prevalence of one kind only of these ores, to the exclusion of the others.

The red oxides of the secondary rocks consist, for the most part, of the red fossiliferous and oolitic ores that accompany the so-called Clinton group of calcareous shales, sandstones, and argillaceous limestones of the upper silurian along their lines of outcrop in Pennsylvania, Maryland, and eastern Tennessee, and from Oneida county, N. Y., westward past Niagara Falls, and through Canada even to Wisconsin. The ore is found in one or two bands, rarely more than one or two feet thick, and the sandstone strata with which they are associated are sometimes so ferruginous as to be themselves workable ores. The true ores are sometimes entirely made up of the forms of fossil marine shells, the original material of which has been gradually replaced by peroxide of iron. The oolitic variety is composed of fine globular particles, united together like the roe of a fish. The ore is also found in compact forms, and in Wisconsin it is in the condition of fine sand or seed. Its composition is very variable, and its per-centage of iron ranges from 40 to 60. By reason of the carbonate of lime diffused through some of the varieties, these work in the blast furnace very freely, and serve extremely well to mix with the silicious ores.

Of the varieties of carbonate of iron, the only ones of practical importance in the United States are the silicious and argillaceous carbonates of the coal formation, and the similar ores of purer character found among the tertiary clays on the western shores of Chesapeake Bay. The former varieties are the chief dependence of the iron furnaces of Great Britain, where they abundantly occur in layers among the shales of the coal formation, interstratified with the beds of coal—the shafts that are sunk for the exploration of one also penetrating beds

of the other. The layers of ore are in flattened blocks, balls, and kidney-shaped lumps, which are picked out from the shales as the beds of these are excavated. The ore is lean, affording from 30 to 40 per cent. of iron; but it is of easy reduction, and makes, when properly treated, iron of fair quality. In Pennsylvania, Ohio, western Virginia, Kentucky, and Tennessee, the ores occur with the same associations as in England; but the supply is, for the most part, very precarious, and many furnaces that have depended upon them are now kept in operation only by drawing a considerable portion of their supplies from the mines of Lake Superior, more than one thousand miles off. Among the horizontally stratified rocks west of the Alleghanies, the same bands of ore are traced over extensive districts, and are even recognized in several of the different states named. One of the most important of these bands is the buhrstone ore, so called from a cellular, flinty accompaniment which usually underlies it, the whole contained in a bed of peculiar fossiliferous limestone. So much carbonate of lime is sometimes present in the ore, that it requires no other flux in the blast furnace. Its per-centage of iron is from 25 to 35. Along the line of outcrop of some of the carbonates are found deposits of hematite ores, the result of superficial changes in the former, due to atmospheric agencies long continued. In southern Ohio, at Hanging Rock particularly, numerous furnaces have been supported by these ores, and have furnished much of the best iron produced at the west.

The carbonates of the tertiary are found in blocks and lumps among the clays along the shores of the Chesapeake at Baltimore, and its vicinity. The ores are of excellent character, work easily in the furnace, make a kind of iron highly esteemed—particularly for the manufacture of nails—and are so abundant that they have long sustained a considerable number of furnaces. They lie near the surface, and are collected by excavating the clay beds and sorting out the balls of ore. The excavations have been carried out in some places on the shore below the level of tide, the water being kept back by coffer dams and steam pumps.

Bog ores, with which the earliest furnaces in the country were supplied, are now little used. They are rarely found in quantities sufficient for running the large furnaces of the present day, and, moreover, make but an inferior, brittle quality of cast iron. They are chiefly found near the coast, and being easily dug, and also reduced to metal with great facility, they proved very convenient for temporary use before the great bodies of ore in the interior were reached. Some furnaces are still running on these ores in the south-west part of New Jersey, and at Snow-hill, on the eastern shore of Maryland, and the iron they make is used to advantage in mixing at the great stove foundries in Albany and Troy with other varieties of cast iron. It increases the fluidity of these, and produces with them a mixture that will flow into and take the forms of the minutest markings of the mould.

Charcoal has been the only fuel employed in the manufacture of iron until anthracite was applied to this purpose, about the year 1840, and still later—in the United States—coke and bituminous coal. So long as wood continued abundant in the iron districts, it was preferred to the mineral fuel, as in the early experience of the use of the latter the quality of the iron it produced was inferior to that made from the same ores with charcoal, and even at the present time, most of the highest-priced irons are made with charcoal. The hard woods make the best coal, and after these, the yellow pine. Hemlock and chestnut are largely used, because of their abundance and cheapness. The charcoal furnaces are of small size compared with those using the denser mineral coal, and their capacity rarely exceeds a production of ten or twelve tons of pig iron in twenty-four hours. In 1840 they seldom made more than four tons a day; the difference is owing to larger furnaces, the use of hot blast, and much more efficient blowing machinery. The consumption of charcoal to the ton of iron is one hundred bushels of hard-wood coal at a minimum, and from this running up to one hundred and fifty bushels or more, according to the quality of the coal and the skill of the manager. The economy of the business depends, in great part, upon the convenience of the supplies of fuel and of ores, of each of which rather more than two tons weight are consumed to every ton of pig iron. As the woods are cut off in the vicinity of the furnaces, the supplies are gradually drawn from greater distances, till at last they are sometimes hauled from ten to fourteen miles. The furnaces near Baltimore have been supplied with pine wood discharged from vessels at the coaling kilns

close by the furnaces. Transportation of the fuel in such cases is a matter of secondary importance.

The mineral coals are a more certain dependence in this manufacture, and are cheaply conveyed from the mines on the great lines of transportation, so that furnaces may be placed anywhere upon these lines, with reference more especially to proximity of ores. Thus they can be grouped together in greater numbers than is practicable with charcoal furnaces. Their establishment, however, involves the outlay of much capital, for the anthracite furnaces are all built upon a large scale, with a capacity of producing from twenty to thirty tons of pig iron a day. This requires machinery of great power to furnish the immense quantities of air, amounting in the large stacks to fifteen tons or more every hour, and propel it through the dense column, of fifty to sixty feet in height, of heavy materials that fill the furnace. The air actually exceeds in weight all the other materials introduced into the furnace, and its efficiency in promoting combustion and generating intensity of heat is greatly increased by the concentration to which it is subjected when blown in under a pressure of six or eight pounds to the square inch. It is rendered still more efficient by being heated to temperature sufficient to melt lead before it is introduced into the furnace; and this demands the construction of heating ovens, through which the blast is forced from the blowing cylinders in a series of iron pipes, arranged so as to absorb as much as possible of the waste heat from the combustible gases that issue from the top of the stack, and are led through these ovens before they are finally allowed to escape. The weight of anthracite consumed is not far from double that of the iron made, and the ores usually exceed in weight the fuel. The flux is a small and cheap item, its weight ranging from one-eighth to one-third that of the ores.

The location of furnaces with reference to the market for the iron is a consideration of no small importance, for the advantages of cheap material may be overbalanced by the difference of a few dollars in the cost of placing in market a product of so little value to the ton weight as pig iron.

The following statement presents the cost of the materials and of other items which go to make up the total expense of the production at different localities near the sea-board. The general expenses at the localities named are reduced to a low amount by the large scale upon which the business is conducted.

At different points on the Hudson river, anthracite furnaces are in operation, which are supplied with hematites from Columbia and Dutchess counties, N. Y., and from the neighboring counties in Massachusetts, at prices varying from $2.25 to $3.00 per ton; averaging about $2.50. They also use magnetic ores from Lake Champlain, and some from the Highlands below West Point, the latter costing $2.50, and the former $3.50 to $4.50 per ton; the average being about $3.50. The quantities of these ores purchased for the ton of iron produced are about two tons of hematite and one of magnetic ore, making the cost for the ores $6.75. Two tons of anthracite cost usually $9, and the flux for fuel about 35 cents. Actual contract prices for labor and superintendence have been $4 per ton. Thus the total expense for the ton of pig iron is about $20.10; or, allowing for repairs and interest on capital, full $21.

In the Lehigh valley, in Pennsylvania, are numerous furnaces, which are supplied with anthracite at the low rate of $3 per ton, or $6 to the ton of iron. The ores are mixed magnetic and hematites, averaging in the proportions used about $3 per ton, or, at the rate consumed of 2½ tons, $7.50 to the ton of iron. Allowing the same amount—$4.35—for other items, as at the Hudson river furnaces, the total cost is $17.85; or, with interest and repairs, nearly $19 per ton. The difference is in great part made up to the furnaces on the Hudson by their convenience to the great markets of New York, Troy, and Albany.

The charcoal iron made near Baltimore shows a higher cost of production than either of the above, and it is also subject to greater expenses of transportation to market, which is chiefly at the rolling mills and nail factories of Massachusetts. Its superior quality causes a demand for the product and sustains the business. For this iron per ton 2½ tons of ore are consumed, costing $3.62½ per ton, or $9.06; fuel, 3½ cords at $2.50, $8.75; flux, oyster shells, 30 cts.; labor (including $1.50 for charring) $2.75; other expenses, $2; total, $22.86.

At many localities in the interior of Pennsylvania and Ohio, iron is made at less cost, but their advantages are often counterbalanced by additional expenses incurred in

delivering the metal, and obtaining the proceeds of its sale. Increased facilities of transportation, however, are rapidly removing these distinctions. At Danville, on the Susquehanna river, Columbia county, Pennsylvania, the cost of production has been reduced to an unusually low amount, by reason of large supplies of ore close at hand, the cheapness of anthracite, and the very large scale of the operations. Pig iron, as shown by the books of the company, has been made for $11 per ton. Its quality, however, was inferior, so that, with the expenses of transportation added, it could not be placed in the eastern markets to compete with other irons. The rolling mills connected with the furnaces afforded the means of converting it into railroad bars, with which, from the increased value of the iron, the cost of transportation was of less moment.

DISTRIBUTION OF THE ORES.

The magnetic and specular ores of the United States are found in the belt of metamorphic rocks—the gneiss, quartz rock, mica and talcose slates, and limestones—which ranges along to the east of the Alleghanies, and spreads over the principal part of the New England states. It is only, however, in certain districts, that this belt is productive in iron ores. The hematites belong to the same group, and the important districts of the three ores may be noticed in the order in which they are met from Canada to Alabama. Similar ores are also abundant in Missouri, and to the south of Lake Superior.

NEW ENGLAND STATES.—In New Hampshire magnetic and specular ores are found in large quantities in a high granitic hill called the Baldface Mountain, in the town of Bartlett. The locality is not conveniently accessible, and its remoteness from coal mines will probably long keep the ore, rich and abundant as it is, of no practical value. At Piermont, on the western border of the state, specular ore, very rich and pure, is also abundant, but not worked. At Franconia a small furnace, erected in 1811, was run many years upon magnetic ores, obtained from a bed of moderate size, and which in 1824 had been worked to the depth of 200 feet. In 1830 the iron establishments of this place were still objects of considerable interest, though from the accounts of them published in the *American Journal of Science* of that year, it appears that the annual production of the blast furnace for the preceding nine years had averaged only about "216 tons of cast iron in hollow ware, stoves, machinery, and pig iron"—a less quantity than is now produced in a week by some of the anthracite furnaces. One forge making bar iron direct from the ore produced forty tons annually, and another 100 tons, consuming 550 bushels of charcoal to the ton. The cost of this, fortunately, was only from $3.75 to $4.00 per hundred bushels. A portion of the product was transported to Boston, the freight alone costing $25 per ton.

In Vermont these ores are found in the metamorphic slates of the Green Mountains, and are worked to some extent for mixing with the hematite ores, which are more abundant, being found in many of the towns through the central portion of the state, from Canada to Massachusetts. In 1850 the number of blast furnaces was ten, but their production probably did not reach 4,000 tons per annum, and has since dwindled away to a much less amount. At the same time there were seven furnaces in Berkshire, Mass., near the hematite beds that are found in the towns along the western line of the state. These had a working capacity of about 12,000 tons of pig iron annually, and this being made from excellent ores, with charcoal for fuel, its reputation was high and the prices remunerative; but as charcoal increased in price, and the cheaper anthracite-made iron improved in quality, the business became unprofitable; so that the extensive hematite beds are now chiefly valuable for furnishing ores to the furnaces upon the Hudson river, where anthracite is delivered from the boats that have come through the Delaware and Hudson canal, and magnetic ores are brought by similar cheap conveyance from the mines on the west side of Lake Champlain. Through Connecticut, down the Housatonic valley, very extensive beds of hematite have supplied the sixteen furnaces which were in operation ten years ago. The great Salisbury bed has already been named. In the first half of the present century it produced from 250,000 to 300,000 tons of the very best ore; the iron from which, when made with cold blast, readily brought from $6 to $10 per ton more than the ordinary kinds of pig iron. The Kent ore bed was of similar character, though not so extensive.

NEW YORK.—Across the New York state line, a number of other very extensive deposits of hematite supported seven blast fur-

naces in Columbia and Dutchess counties, and now furnish supplies to those along the Hudson river. In Putnam county, magnetic ores succeed the hematites, and are developed in considerable beds in Putnam Valley, east from Cold Spring, where they were worked for the supply of forges during the last century. These beds can again furnish large quantities of rich ore. On the other side of the river, very productive mines of magnetic ore have been worked near Fort Montgomery, six miles west from the river. At the Greenwood furnace, back from West Point, was produced the strongest cast iron ever tested, which, according to the report of the officers of the ordnance department, made to Congress in 1856, after being remelted several times to increase its density, exhibited a tenacity of 45,970 lbs. to the square inch. The beds at Monroe, near the New Jersey line, are of vast extent; but a small portion of the enormous quantities of ore in sight, however, makes the best iron. Mining was commenced here in 1750, and a furnace was built in 1751, but operations have never been carried on upon a scale commensurate with the abundance of the ores. In the northern counties of New York, near Lake Champlain, are numerous mines of rich magnetic ores. Some of the most extensive bloomary establishments in the United States are supported by them in Clinton county, and many smaller forges are scattered along the course of the Ausable river, where water power near some of the ore beds presents a favorable site. Bar iron is made at these establishments direct from the ores; and at Keeseville nail factories are in operation, converting a portion of the iron into nails. In Essex county there are also many very productive mines of the same kind of ore, and Port Henry and its vicinity has furnished large quantities, not only to the blast furnaces that were formerly in operation here, but to those on the Hudson, and to puddling furnaces in different parts of the country, particularly about Boston. In the interior of Essex county, forty miles back from the lake, are the extensive mines of the Adirondac. The ores are rich as well as inexhaustible, but the remoteness of the locality, and the difficulty attending the working of them, owing to their contamination with titanium, detract greatly from their importance. On the other side of the Adirondac mountains, in St. Lawrence county, near Lake Ontario, are found large beds of specular ores, which have been worked to some extent in several blast furnaces. They occur along the line of junction of the granite and the Potsdam sandstone. The iron they make is inferior—suitable only for castings. The only other ores of any importance in the state are the fossiliferous ores of the Clinton group, which are worked near Oneida Lake, and at several points along a narrow belt of country near the south shore of Lake Ontario. They have sustained five blast furnaces in this region, and are transported in large quantities by canal to the anthracite furnaces at Scranton, in Pennsylvania, the boats returning with mineral coal for the furnaces near Oneida Lake.

New Jersey.—From Orange county, in New York, the range of gneiss and hornblende rocks, which contain the magnetic and specular ores, passes into New Jersey, and spreads over a large part of Passaic and Morris, and the eastern parts of Sussex and Warren counties. The beds of magnetic ore are very large and numerous, and have been worked to great extent, especially about Ringwood, Dover, Rockaway, Boonton, and other towns, both in blast furnaces and in bloomaries. At Andover, in Sussex county, a great body of specular ores furnished for a number of years the chief supplies for the furnaces of the Trenton Iron Company, situated at Philipsburg, opposite the mouth of the Lehigh. On the range of this ore, a few miles to the north-east, are extensive deposits of Franklinite iron ore accompanying the zinc ore of this region. This unusual variety of ore consists of peroxide of iron about 66 per cent., oxide of zinc 17, and oxide of manganese 16. It is smelted at the works of the New Jersey Zinc Company at Newark, producing annually about 2,000 tons of pig iron. The metal is remarkable for its large crystalline faces and hardness, and is particularly adapted for the manufacture of steel, as well as for producing bar iron of great strength.

As the forests, which formerly supplied abundant fuel for the iron works of this region, disappeared before the increasing demands, attention was directed to the inexhaustible sources of anthracite up the Lehigh valley in Pennsylvania, with which this iron region was connected by the Morris canal and the Lehigh canal; and almost the first successful application of this fuel to the smelting of iron ores upon a large scale was made at Stanhope, by Mr. Edwin Post. A new

era in the iron manufacture was thus introduced, and an immense increase in the production soon followed, as the charcoal furnaces gave place to larger ones constructed for anthracite. The Lehigh valley, lying on the range of the iron ores toward the southwest, also produced large quantities of ore, which, however, was almost exclusively hematite. Hence, an interchange of ores has been largely carried on for furnishing the best mixtures to the furnaces of the two portions of this iron district; and the operations of the two must necessarily be considered together. The annual production, including that of the bloomaries of New Jersey, has reached, within a few years, about 140,000 tons of iron. But in a prosperous condition of the iron business this can be largely increased without greatly adding to the works already established, while the capacity of the iron mines and supplies of fuel are unlimited. The proximity of this district to the great cities, New York and Philadelphia, adds greatly to its importance.

PENNSYLVANIA.—Although about one-third of all the iron manufactured in the United States is the product of the mines of Pennsylvania, and of the ores carried into the state, the comparative importance of her mines has been greatly overrated, and their large development is rather owing to the abundant supplies of mineral coal conveniently at hand for working the ores, and, as remarked by Mr. Lesley ("Iron Manufacturer's Guide," p. 433), "to the energetic, persevering German use for a century of years of what ores do exist, than to any extraordinary wealth of iron of which she can boast. Her reputation for iron is certainly not derived from any actual pre-eminence of mineral over her sister states. New York, New Jersey, Virginia, and North Carolina, are far more liberally endowed by nature in this respect than she. The immense magnetic deposits of New York and New Jersey almost disappear just after entering her limits. The brown hematite beds of her great valley will not seem extraordinary to one who has become familiar with those of New York, Massachusetts, Vermont, Virginia, and Tennessee. Her fossil ores are lean and uncertain compared with those of the south; and the carbonate and hematized carbonate outcrops in and under her coal measures will hardly bear comparison with those of the grander outspread of the same formations in Ohio, Kentucky, and western Virginia." The principal sources of iron in the state are, first, the hematites of Lehigh and Berks counties—the range continuing productive through Lancaster, also on the other side of the intervening district of the new red sandstone formation. The ores are found in large beds in the limestone valley, between the South and the Kittatinny mountains; those nearest the Lehigh supply the furnaces on that river, already amounting to twenty-three in operation and four more in course of construction, and those nearer the Schuylkill supply the furnaces along this river. The largest bed is the Moselem, in Berks county, six miles west-south-west from Kutztown. It has been very extensively worked, partly in open excavation and partly by underground mining, the workings reaching to the depth of 165 feet. Over 20,000 tons a year of ore have been produced, at a cost of from $1.30 to $1.50 per ton.

Magnetic ores are found upon the Lehigh, or South mountain, the margin on the south of the fertile limestone valley which contains the hematite beds. These, however, are quite unimportant, the dependence of the great iron furnaces of the Lehigh for these ores being on the more extensive mines of New Jersey; while the only supplies of magnetic ores to the furnaces of the Schuylkill and the Susquehanna are from the great Cornwall mines, four miles south of Lebanon. An immense body of magnetic iron ore, associated with copper ores, has been worked for a long time at this place, at the junction of the lower silurian limestones and the red sandstone formation. The bed lies between dikes of trap, and exhibits peculiarities that distinguish it from the other bodies of iron ore on this range. The Warwick, or Jones' mine, in the south corner of Berks county, resembles it in some particulars. Its geological position is in the upper slaty layers of the Potsdam sandstone, near the meeting of this formation with the new red sandstone. Trap dikes penetrate the ore and the slates, and the best ore is found at both mines near the trap. Copper ores are also found in connection with the iron ores, but not in workable quantities. The Warwick mine has been worked more than seventy-five years, and has yielded for twenty years together an average of 7,000 tons of ore. Other magnetic ores are found in Lancaster and Chester counties, but are quite unimportant as sources of iron. Along the Maryland line, on both sides of the Susque-

hanna, chrome iron has been found in considerable abundance in the serpentine rocks, and has been largely and very profitably mined for home consumption and for exportation. It furnishes the different chrome pigments, and their preparation has been carried on chiefly at Baltimore.

A portion of the hematites which supply the furnaces on the Schuylkill, occur along a narrow limestone belt of about a mile in width, that crosses the Schuylkill at Spring Mill, and extends north-east into Montgomery county, and south-west into Chester county. Their production has been very large, and that of the furnaces of the Schuylkill valley dependent upon these and the other mines of this region has been rated at 100,000 tons of iron annually.

The great Chestnut hill hematite ore bed, three and a half miles north-east of Columbia, Lancaster county, covers about twelve acres of surface, and has been worked in numerous great open excavations to about 100 feet in depth, the ore prevailing throughout among the clays and sands from top to bottom. "The floor of the mine is hard, white Potsdam sandstone, or the gray slaty layers over it. The walls show horizontal wavy layers of blue, yellow, and white laminated, unctuous clays, from forty to sixty feet deep, containing ore, and under these an irregular layer of hard concretionary, cellular, fibrous, brown hematite from ten to thirty feet thick down to the sandstone." ("Iron Manufacturer's Guide, p. 562.") In the accompanying wood-cut, the darkly shaded portions represent the hematites, while the lighter portions above are chiefly clays. Professor Rogers supposes that the ore has leached down from the upper slaty beds through which it was originally diffused, and has collected upon the impervious sandstone, which in this vicinity is the first water bearing stratum for the wells.

CHESTNUT HILL MINE.

The repeated occurrence of the lower silurian limestones and sandstones along the valleys of central Pennsylvania, from the Susquehanna to the base of the Alleghany mountain, is accompanied through these valleys with numerous beds of hematite; and to the supplies of ore they have furnished for great numbers of furnaces, is added the fossiliferous ore of the Clinton group, the outcrop of which is along the slopes of the ridges and around their ends. Many furnaces have depended upon this source of supply alone. As stated by Lesley, there were, in 1857, 14 anthracite furnaces that used no other, and 11 anthracite furnaces which mixed it either with magnetic ore or hematite, or with both. Montour's ridge, at Danville, Columbia county, referred to on page 24, is one of the most remarkable localities of this ore. Professor Rogers estimated, in 1847, that there were 20 furnaces then dependent upon the mines of this place, and producing annually an average of 3,000 tons of iron each, with a consumption of 9,000 tons of ore, or a total annual consumption of 180,000 tons. At this rate, he calculated that the available ore would be exhausted in 20 years.

Between the Clinton group and the coal measures are successive formations of limestones, sandstones, shales, etc., which form a portion of the geological column of many thousand feet in thickness; and among these strata, ores like the carbonates of the coal measures are occasionally developed, and these are recognized and worked at many localities along the outcrop of the formations to

which they belong. Though of some local importance, they do not add very largely to the iron production of the state. Along the summit of the Alleghany mountain the base of the coal measures is reached, which thence spread over the western portion of the state, nearly to its northern line. The ores which belong to this formation are chiefly contained among its lower members, and found in the outcrop of these around the margin of the basin. At some localities they have been obtained in considerable abundance, and many furnaces have run upon them alone; but for large establishments of several furnaces together, they prove a very uncertain dependence.

MARYLAND.—The metamorphic belt crosses this state back of Baltimore, and is productive in chromic iron and copper ores, rather than in magnetic and specular ores. Some of the former, highly titaniferous, have been worked near the northern line of the state, on the west side of the Susquehanna; and at Sykesville, on the Potomac, a furnace has been supplied with specular ores from its vicinity. Several hematite beds within twenty miles of Baltimore have supplied considerable quantities of ore for mixture with the tertiary carbonates, upon which the iron production of the state chiefly depends. Beds of these occur near the bay from Havre de Grace to the District of Columbia. In the western part of the state large furnaces were built at Mount Savage and Lonaconing to work the ores of the coal formation; but the supply has proved insufficient to sustain them. In 1853 the capacity of the blast furnaces of the state was equal to a production of over 70,000 tons of iron. This, however, has never been realized.

SOUTHERN STATES.—South of Maryland the same iron belt continues through Virginia, the Carolinas, and Georgia; and although it is often as productive in immense beds of the three varieties of ore—the magnetic, specular, and hematite—as in the other states along its range, these resources add comparatively little to the material wealth of the states to which they belong. Through Virginia, east and west of the Blue Ridge, hematite ores abound in the limestone valleys, and magnetic ores are often in convenient proximity to them. Many small furnaces have worked them at different times, but their product was always small. Three belts of magnetic ore, associated with specular iron and hematites, are traced across the midland counties of North Carolina, and have furnished supplies for furnaces and forges in a number of counties—as Lincoln, Cleveland, Rutherford, Stokes, Surry, Yadkin, Catawba; and Chatham, Wake, and Orange counties upon the eastern belt. The belt of ore from Lincoln county passes into South Carolina, and through York, Union, and Spartanburg districts. It crosses the Broad River at the Cherokee ford, and though the whole belt is only half a mile wide, it presents numerous localities of the three kinds of ore, and of limestone also in close proximity, and finely situated for working. Several other localities are noticed in the "State Geological Report," by M. Tuomey, who remarks, on page 278, that "if iron is not manfactured in the state as successfully as elsewhere, it is certainly not due to any deficiency in natural advantages." In northern Georgia the ferruginous belt is productive in immense bodies of hematite, associated with magnetic and specular ores, in the Allatoona hills, near the Etowah river, in Cherokee and Cass counties. This, which appears to be one of the great iron districts of the United States, though bountifully provided with all the materials required in the manufacture, and traversed by a railroad which connects it with the bituminous coal mines of eastern Tennessee, supports only six small charcoal furnaces of average capacity, not exceeding 600 or 700 tons per annum each. In Alabama, hematites and specular ores accompany the belt of silurian rocks to its southern termination, and are worked in a few bloomary fires and two or three blast furnaces. The fossiliferous ore of the Clinton group is also worked in this state.

TENNESSEE in 1840 ranked as the third iron-producing state in the Union. The counties ranging along her eastern border produced hematite ores, continuing the range of the silurian belt of the great valley of Virginia; those bordering the Clinch river produced the fossil ore of the Clinton group, there known as the dyestone ore; and western Tennessee presented a very interesting and important district of hematites belonging to the subcarboniferous limestone in the region lying east of the Tennessee and south of the Cumberland river.* The

* "It is remarkable that most of these deposits

furnaces of this district, which have numbered 42 in all, were the greater part of them in Dickson, Montgomery, and Stewart counties. They were all supplied with charcoal for fuel, at a cost of $4 per hundred bushels. In 1854 the product of pig iron was 37,918 tons; but it gradually declined to 27,050 tons in 1857; and in August, 1858, only 15 furnaces were in operation. The secretary of the American Iron Association, in his report of 1858, remarks that in spite of the old establishments of the manufacture, and wealth of ore deposits south of the Kentucky-Tennessee line, the capital and energy of the trade is moving northward down the two great rivers of that region toward the Ohio and its rolling mills.

KENTUCKY.—The western part of this state contains, in the counties of Calloway, Trigg, Lyon, Caldwell, Livingston, and Crittenden, an important district of hematite ores—the continuation northward of that of Tennessee. In 1857 10 charcoal furnaces produced 15,600 tons of iron. Eastern Kentucky, however, has a much more productive district in the counties of Carter and Greenup, which is an extension south of the Ohio of the Hanging Rock iron district of Ohio. The ores are carbonates and hematite outcrops of carbonates, belonging to the coal measures and the subcarboniferous limestone. They are in great abundance; a section of 740 feet of strata terminating below with the limestone named, presenting no less than 14 distinct beds of ore, from three inches to four feet each, and yielding from 25 to 60 per cent. of iron. One bed of 32 per cent. iron contains also 11 per cent. bitumen—a composition like that of the Scotch "black band" ore. Others contain so much lime, that the ores are valuable for fluxing as well as for producing iron. The furnaces use charcoal and coke. Their production, taken with that of the same district in Ohio, places this region, as will be seen in the tables to follow, among the first in importance in the United States.

OHIO.—The ores of this state, like those of Kentucky, belong almost exclusively to the coal measures and the limestone formations beneath. In both states some of the fossiliferous ore also is found, but it is comparatively unimportant. The productive beds are near the base of the coal formation, ranging from the Hanging Rock district of Scioto and Lawrence counties north-east through Jackson, Hocking, Athens, Perry, Muskingum, Tuscarawas, Mahoning, and Trumbull counties, to the line of Mercer county in Pennsylvania. The uncertain character of the ores, both as to supply and quality, is strikingly shown by the fact that many of the furnaces of the more northern counties depend for a considerable portion —one-fourth or more—of the ores they use upon the rich varieties from Lake Superior and Lake Champlain. Although the long transportation makes these ores cost nearly three times as much per ton as those of the coal formation, some furnaces find it more profitable to use the former, even in the proportion of three-fourths, on account of the much better iron produced, the greater number of tons per day, and the less consumption of fuel to the ton. The fuel employed is charcoal in many of the furnaces; some have introduced raw bituminous coal to good advantage.

INDIANA, ILLINOIS, and IOWA contain no important bodies of iron ore. The coal measures, which cover large portions of these states, are productive in some small quantities of the carbonates, in the two former, which give support to a very few furnaces; but in Iowa they contain no workable beds at all.

MICHIGAN.—The iron region of this state is in the upper peninsula, between Green Bay and Lake Superior. Magnetic and specular ores are found throughout a large portion of this wild territory, in beds more extensive than are seen in any other part of the United States—perhaps than are anywhere known. The district approaches within twelve miles of the coast of Lake Superior, from which it is more conveniently reached than from the south side of the peninsula. The ores are found in a belt of crystalline slates, of six to ten miles in

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are of what is called pot ore, that is, hollow balls of ore, which, when broken open, look like broken caldrons. One of them, preserved by Mr. Lewis, is 8 feet across the rim! Another is six feet across. The majority are crossed within by purple diaphragms or partitions of ore, and the interstitial spaces are filled with yellow ochre. Some, like the great eight-foot pot, are found to be full of water. The inside surface is mammillary, irregular, sometimes botryoidal or knobby, but the outside is pretty smooth and regular. All these pots were undoubtedly once balls of carbonates of lime and iron segregated in the original deposit. . . . Gypsum and pyrites are both often found in these Tennessee pots."—*Iron Manufacturer's Guide, p.* 603.

width, that extends west from the lake shore, and is bounded north and south by a granitic district. They are developed in connection with great dikes and ridges of trap, which range east and west, and dip with the slates at a high angle toward the north. The ores also have the same direction and dip. Localities of them are of frequent occurrence for eighteen miles in a westerly direction from the point of their nearest approach to Lake Superior. A second range of the beds is found along the southern margin of the slate district; and about thirty miles back from the lake, where the slates extend south into Wisconsin, similar developments of ore accompany them to the Menomonee river and toward Green Bay. The quality of the ore found at different places varies according to the amount of quartz, jasper, hornblende, or feldspar that may be mixed with it; but enormous bodies are nearly pure ore, yielding from 68 to 70 per cent. of iron, and free from a trace even of manganese, sulphur, phosphorus, or titanium. A single ridge, traced for about six miles, rising to a maximum height of fifty feet above its base, and spreading out to a width of one thousand feet, has been found to consist of great longitudinal bands of ore, much of which is of this perfectly pure character. Another ridge presents precipitous walls fifty feet high, composed in part of pure specular ore, fine grained, of imperfect slaty structure, and interspersed with minute crystals of magnetic oxide; and in part of these minute crystals alone. Another body of one thousand feet in width, and more than a mile long, forms a hill one hundred and eighty feet high, which is made up of alternate bands of pure, fine grained, steel-gray peroxide of iron, and deep red jaspery ore—the layers generally less than a fourth of an inch in thickness, and curiously contorted. Their appearance is very beautiful in the almost vertical walls. On one of the head branches of the Esconaba is a cascade of thirty-seven feet in height, the ledge over which the water falls being a bed of peroxide of iron, intermixed with silicious matter.

For the supply of the few furnaces and bloomary establishments already in operation in this district, and for the larger demands of distant localities, the ores are collected from open quarries, and from the loose masses lying around. A railroad affords the means of transporting them to Marquette, on the lake shore, whence they are shipped by vessels down the lake. The business already amounts to more than 100,000 tons per annum, and is increasing very rapidly. The name Bay de Noquet and Marquette railroad suggests a southern terminus of this road on Green Bay, and when an outlet is opened in this direction, the production of iron ores will no doubt exceed that of any other region upon the globe. Large quantities will be reduced with charcoal in blast furnaces and bloomaries in the region itself; and when the forests in the vicinity of the works are cut off, the extensive timbered lands around Lake Michigan and Lake Huron will furnish inexhaustible supplies of fuel, which may be brought in vessels to the furnaces, as the pine wood from the forests around Chesapeake Bay has long been delivered to the furnaces on its western shore. Anthracite and bituminous coal will also be brought back as return cargoes by the vessels that carry the ores to the coal fields of Ohio and Pennsylvania. With its vast inland navigation and wonderful resources of iron and of copper also, the north-western portion of our country promises to be the scene of a more extended and active industry than has ever grown out of the mines of any part of the world.

Wisconsin.—Magnetic and specular ores in bodies, somewhat resembling those of the region just described, are found in the extreme northern part of Wisconsin, upon what is known as the Penokie range, distant about 25 miles from Chegwomigon Bay, Lake Superior. Bad River and Montreal River drain this district. The ores, from their remoteness, are not soon likely to be of practical importance. Other immense bodies of these ores, estimated to contain many millions of tons, are found on Black River, which empties into the Mississippi below St. Croix river, on the line of the Land Grant Branch railroad. A furnace has been built by a German company to work these mines. In the eastern part of Wisconsin the oolitic ore of the Clinton group is met with in Dodge and Washington counties, and again at Depere, seven miles south-east of Green Bay. In the town of Hubbard, Dodge county, forty miles west from Lake Michigan, is the largest deposit of this ore ever discovered. It spreads in a layer ten feet thick over 500 acres, and is estimated to contain 27,000,000 tons. It is in grains, like sand, of glistening red color, staining the hands. Each grain has a minute nucleus of silex, around which the

oxide of iron collected. The per-centage of metal is about fifty. This ore will probably be worked near Milwaukee with Lake Superior ores, the La Crosse railroad, which passes by the locality, already affording the means of cheap transportation.

Missouri.—This state must be classed among the first in the abundance of its iron ores, though up to this time comparatively little has been done in the development of its mines. The ores are exclusively hematites, and the magnetic and specular, and all occur in the isolated district of silurian rocks—formations which almost everywhere else in the western middle states are concealed beneath the more recent formations. In the counties along the line of the Pacific railroad south-west branch, Prof. Swallow, the state geologist, reports no less than ninety localities of hematite. These are in Jefferson, Franklin, Crawford, Phelps, Pulaski, Marion, Green, and other counties. The first attempts to melt iron in Missouri, and probably in any state west of Ohio, were made in Washington county, in 1823 or 1824, and with the hematites of the locality were mixed magnetic ores from the Iron mountain. In Franklin county there is but one furnace, though on both sides of the Maramec are beds of hematite pipe ore, which cover hundreds of acres. The Iron mountain district is about sixty miles back from the Mississippi river (the nearest point on which is St. Genevieve), and extends from the Iron mountain in the south-east part of Washington county into Madison county. It includes three important localities of specular ore: the Iron Mountain, Pilot Knob, and Shepherd mountain. The first is a hill of gentle slopes, 228 feet high above its base, and covering about 500 acres—a spur of the porphyritic and syenitic range on the east side of Bellevue valley. In its original state, as seen by the writer in 1841, it presented no appearance of rock in place, its surface was covered with a forest of oak, the trees thriving in a soil wholly composed of fragments of peroxide of iron, comminuted and coarse mixed together. Loose lumps of the ore were scattered around on every side but the north, and upon the top were loose blocks of many tons weight each. Mining operations, commenced in 1845, developed only loose ore closely packed with a little red clay. An Artesian well was afterward sunk to the depth of 152 feet. It passed through the following strata in succession: iron ore and clay, 16 feet; sandstone, 34 feet; magnesian limestone, 7½ inches; gray sandstone, 7½ inches; "hard blue rock," 27 feet; "pure iron ore," 5 feet; porphyritic rock, 7 feet; iron ore 50 feet to the bottom. The ore appears to be interstratified with the silicious rocks with which it is associated in a similar manner to its occurrence at the other localities, and data are yet wanting to determine how much may exist in the hill itself, as well as below it. Enough is seen to justify any operations, however extensive, that depend merely upon continued supplies of ore. In quality the ore is a very pure peroxide; it melts easily in the furnace, making a strong forge pig, well adapted for bar iron and steel. Two charcoal furnaces have been in operation for a number of years, and up to the close of 1854 had produced 24,600 tons of iron. The flux is obtained from the magnesian limestone, which spreads over the adjoining valley in horizontal strata.

Pilot Knob is a conical hill of 580 feet height above its base, situated six miles south of the Iron mountain. Its sides are steep, and present bold ledges of hard, slaty, silicious rock, which lie inclined at an angle of 25° to 30° toward the south-west. Near the top the strata are more or less charged with the red peroxide of iron, and loose blocks of great size are seen scattered around, some of them pure ore, and some ore and rock mixed. At the height of 440 feet above the base, where the horizontal section of the mountain is equal to an area of fifty-three acres, a bed of ore is exposed to view on the north side, which extends 273 feet along its line of outcrop, and is from nineteen to twenty-four feet in thickness. It is included in the slaty rocks, and dips with them. Other similar beds are said to occur lower down the hill; and higher up others are met with to the very summit. The peak of the mountain is a craggy knob of gray rocks of ore, rising sixty feet in height, and forming so conspicuous an object as to have suggested the name by which the hill is called. The ore is generally of more slaty structure than that of the Iron mountain, and some of it has a micaceous appearance. The quantity of very pure ore conveniently at hand is inexhaustible. The production of iron will be limited more for want of abundance of fuel than of ore. Charcoal, however, may be obtained in abundance for many years to come, and bituminous coal may also be

brought from the coal mines of Missouri and Illinois, as the ores also can be carried to the river to meet there the fuel. The locality is already connected with St. Louis by a railroad. A blast furnace was built here in 1846, and another in 1855. A bloomary with six fires was started in 1850, and has produced blooms at an estimated cost of $30 per ton.

Shepherd mountain, about a mile distant from the Pilot Knob toward the south-west, is composed of porphyritic rocks, which are penetrated with veins or dikes of both magnetic and specular ores. These run in various directions, and the ores they afford are of great purity. They are mined to work together with those of the Pilot Knob. The mountain covers about 800 acres, and rises to the height of 660 feet above its base. Other localities of these ores are also known, and the occurrence of specular ore is reported by the state geologists in several other counties, as Phelps, Crawford, Pulaski, La Clede, etc.

In other parts of the United States and its territories great bodies of iron ore are known to exist, which will probably become valuable at some future time. In Arkansas are found very pure magnetic ores, remarkable for their high magnetic property. Near Santa Fé, in New Mexico, specular ores abound, which must before long be used to furnish the iron required for that region, instead of transporting it, as at present, at heavy cost from the iron districts near the Mississippi river. In California reports are made of the existence of masses of rich ores, comparable in extent even with those of Lake Superior.

IRON MANUFACTURE.

Iron is known in the arts chiefly in three forms—cast iron, steel, and wrought iron. The first is a combination of metallic iron, with from 1¼ to 5 or 5½ per cent. of carbon; the second is metallic iron combined with ¼ to 1¼ per cent. of carbon; and the third is metallic iron, free as may be from foreign substances. These differences of composition are accompanied with remarkable differences in the qualities of the metal, by which its usefulness is greatly multiplied. The three sorts are producible as desired directly from the ores, and they are also convertible one into the other; so that the methods of manufacture are numerous, and new processes are continually introduced. The production of wrought iron direct from the rich natural oxides, was until modern times the only method of obtaining the metal. Cast iron was unknown until the 15th century. Rude nations early learned the simple method of separating the oxygen from the ores by heating them in the midst of burning charcoal; the effect of which is to cause the oxygen to unite with the carbon in the form of carbonic acid or carbonic oxide gas, and escape, leaving the iron free, and in a condition to be hammered at once into bars. The heat they could command in their small fires was insufficient to effect the combination of the iron, too, with the carbon, and produce the fusible compound known as cast iron. In modern times the great branch of the business is the production of pig metal or cast iron in blast furnaces; and this is afterward remelted and cast in moulds into the forms required, or it is converted into wrought iron to serve some of the innumerable uses of this kind of iron, or to be changed again into steel. In this order the principal branches of the manufacture will be noticed.

The production of pig metal in blast furnaces is the most economical mode of separating iron from its ores, especially if these are not extremely rich. The process requiring little labor, except in charging the furnaces, and this being done in great part by labor-saving machines, it can be carried on upon an immense scale with the employment of few persons, and most of those ordinary laborers. The business, moreover, has been greatly simplified and its scale enlarged by the substitution of mineral coal for charcoal—the latter fuel, indeed, could never have been supplied to meet the modern demands of the manufacture.

Blast furnaces are heavy structures of stone work, usually in pyramidal form, built upon a base of 30 to 45 feet square, and from 30 to 60 feet in height. The outer walls, constructed with immense solidity and firmly bound together, inclose a central cavity, which extends from top to bottom and is lined with large fire brick of the most refractory character, and specially adapted in their shapes to the required contour of the interior. The form of this cavity is circular in its horizontal section, and from the top goes on enlarging to the lower portion, where it begins to draw in by the walls changing their slope toward the centre. This forms what are called the boshes of the furnace—the part which supports the great weight of the ores

and fuel that fill the interior. For ores that melt easily and fast they are made steeper than for those which are slowly reduced. The boshes open below into the hearth—the central contracted space which the French name the crucible of the furnace. The walls of this are constructed of the most refractory stones of large size, carefully selected for their power to resist the action of fire, and seasoned by exposure for a year or more after being taken from the quarry. Being the first portion to give out, the stack is built so that they can be replaced when necessary. The hearth is reached on each side of the stack by an arch, extending in from the outside. On three sides the blast is introduced by iron pipes that pass through the hearth-stones, and terminate in a hollow tuyere, which is kept from melting by a current of water brought by a lead pipe, and made to flow continually through and around its hollow shell. (See fig. *d*.) The fourth side is the front or working-arch of the furnace, at the bottom of which access is had to the melted materials as they collect in the receptacle provided for them at the base of the hearth or crucible. This arch opens out into the casting-house, upon the floor of which are the beds in the sand for moulding the pigs into which the iron is to be cast. Upon the top of the stack around the central cavity are constructed, in first-class furnaces, large flues, which open into this cavity for the purpose of taking off a portion of the heated gaseous mixtures, that they may be conveyed under the boilers, to be there more effectually consumed, and furnish the heat for raising steam for the engines. A portion of the gases is also led into a large heating-oven, usually built on the top of the stack, in which the blast (distributed through a series of cast iron pipes) is heated by the combustion. These pipes are then concentrated into one main, which passes down the stack and delivers the heated air to the tuyeres, thus returning to the furnace a large portion of the heat which would otherwise escape at the top, and adding powerfully to the efficiency of the blast by its high temperature. The boilers, also conveniently arranged on the top of the furnace, especially when two furnaces are constructed near together, are heated by the escape gases without extra expense of fuel, and they furnish steam to the engines, which are usually placed below them. On account of the enormous volume of air, and the great pressure at which it is blown into the furnace, the engines are of the most powerful kind, and the blowing cylinders are of great dimensions and strength. Some of the large anthracite furnaces employ cylinders 7½ feet diameter, and 9 feet stroke. One of these running at the rate of 9 revolutions per minute, and its piston acting in both directions, should propel every minute 7,128 cubic feet of air (less the loss by leakage) into the furnace—a much greater weight than that of all the other materials introduced. It is, moreover, driven in at a pressure (produced by the contracted aperture of the nozzle of the tuyeres in relation to the great volume of air) of 7 or 8 lbs. upon the square inch. Two such cylinders answer for a pair of the largest furnaces, and should be driven by separate engines, so that in case of accident the available power may be extended to either or both furnaces. It is apparent that the engines, too, should be of the largest class and most perfect construction; for the blast is designed to be continued with only temporary interruptions that rarely exceed an hour at a time, so long as the hearth may remain in running order—a period, it may be, of 18 months, or even 4 or 5 years. Furnaces were formerly built against a high bank, upon the top of which the stock of ore and coal was accumulated, and thence carried across a bridge, to be delivered into the tunnel-head or mouth of the furnace. The more common arrangement at present is to construct, a little to one side, an elevator, provided with two platforms of sufficient size to receive several barrows. The moving power is the weight of a body of water let into a reservoir under the platform when it is at the top. This being allowed to descend with the empty barrows, draws up the other platform with its load, and the water is discharged by a self-regulating valve at the bottom. The supply of water is furnished to a tank in the top either by pumps connected with the steam engine or by the head of its source.

The furnaces of the United States, though not congregated together in such large numbers as at some of the great establishments in England and Scotland, are unsurpassed in the perfection of their construction, apparatus, and capacity; and none of large size are probably worked in any part of Europe with such economy of materials. The accompanying wood-cut (fig. *a*) will give an idea of the form and dimensions of one of first class, and may be taken to represent one of the

pair of furnaces belonging to the Thomas Iron Company, in the Lehigh valley, Pennsylvania, though the plan is so far modified in the cut as to place the working-arch and casting-house upon a different side. The boiler-stack, which extends 80 feet in length along the level of the oven, O, for heating the blast, is not represented. A duplicate boiler-stack and heating-oven, connected with the other furnace, also stand upon the high platform, which extends from the top of one furnace-stack to that of the other—a distance of about 110 feet, and at an elevation above the bottom of the hearth of 45 feet. The furnace is carried 15 feet higher than this by a low, dome-like structure, in fire brick, which contains an annular flue, EE, 6 feet high and 4 feet wide, into which the gaseous products of combustion are drawn through the horizontal flues, FF, 8 in all. From the annular ring one-fourth of the gases pass into the heating-oven, O, and are burned around the pipes, sufficient atmospheric air being admitted for their combustion; and the other three-fourths flow under the five boilers, and are consumed in the great chamber, 80 feet long, 6 feet high, and about 16 feet wide, beneath them. This is seen in fig. *b*, which is a horizontal section on the top of the stacks.

In fig. *a*, A is the central cavity of the furnace, 60 feet in height, 18 feet in diameter at the top of the boshes, BB (14 feet above the bottom), and 8 feet in diameter at the tunnel-head, on the level of the charging platform, PP. The boshes form a cone like a funnel, and the hearth, H, then represents the neck of the funnel. This is 5 feet high, and 7 feet across. The blast is admitted on three sides, by four tuyeres, side by side, in each arch. It is brought down from the heating-oven by the main pipe, *hb*, which is 18 inches in diameter. On the fourth side of the furnace is the working-arch, W, by which access is had to the hearth for letting out the cinder and metal. The former flows from time to time over the dam-stone, *d*, and down the cinder-slope, *m*, and the latter is let out through an opening under the dam-stone as often as it rises so as to threaten running over. The block, T, in front of the hearth, is supported by the side stones, and stretches across from one to the other. Under this the workmen thrust long iron bars, and pry up and loosen the cinder whenever it gets thick and endangers obstruction of the blast. The lining of furnaces is made of the best of fire brick, a foot or more deep, moulded in shapes for the circle. Behind this lining is a narrow space filled with sand, and back of this is another fire-brick lining. The heating-oven, as designed in the cut, is 25 feet high, and about the same length, by 10 feet wide. This gives abundant space for the gases to circulate freely and be thoroughly consumed before escaping through the chimneys on the top. In this oven are 5 rows of arched oval pipes, 12 in each row. They stand 10 feet high, arranged on 6 bed-pipes, and their size is 8 by 4 inches. The blast set in operation in the space below the platform, is conducted into the receiver, R, which is a cylinder of boiler-plate iron, 108 feet long and 6½ feet diameter, designed to give uniformity of pressure to the current of air which passes from it to the heating-oven, and thence into the furnace. These receivers are of various forms, and are necessarily of great strength, to resist the pressure of the blast over their expanded surface. The chimney, S, in the cut, is connected with one of the boiler-stacks. This is more clearly seen in fig. *b*. The half omitted is a duplicate of that drawn, and would, if completed, show the other furnace to which the boilers and the chimney, S, belong. The other boilers, *b b*, are connected with the furnace, A. The manner of introducing the blast through the sides of the hearth is shown in fig. *c*, which is a horizontal section through the tuyeres, *t*.

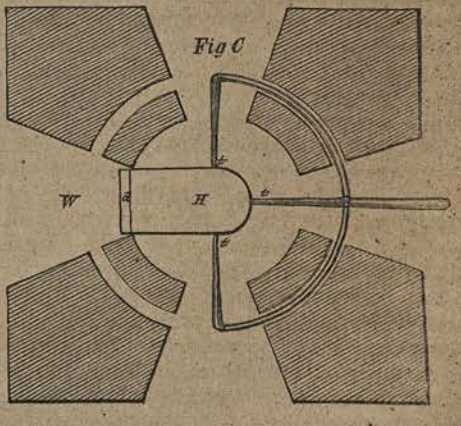


Fig C

Fig. a.

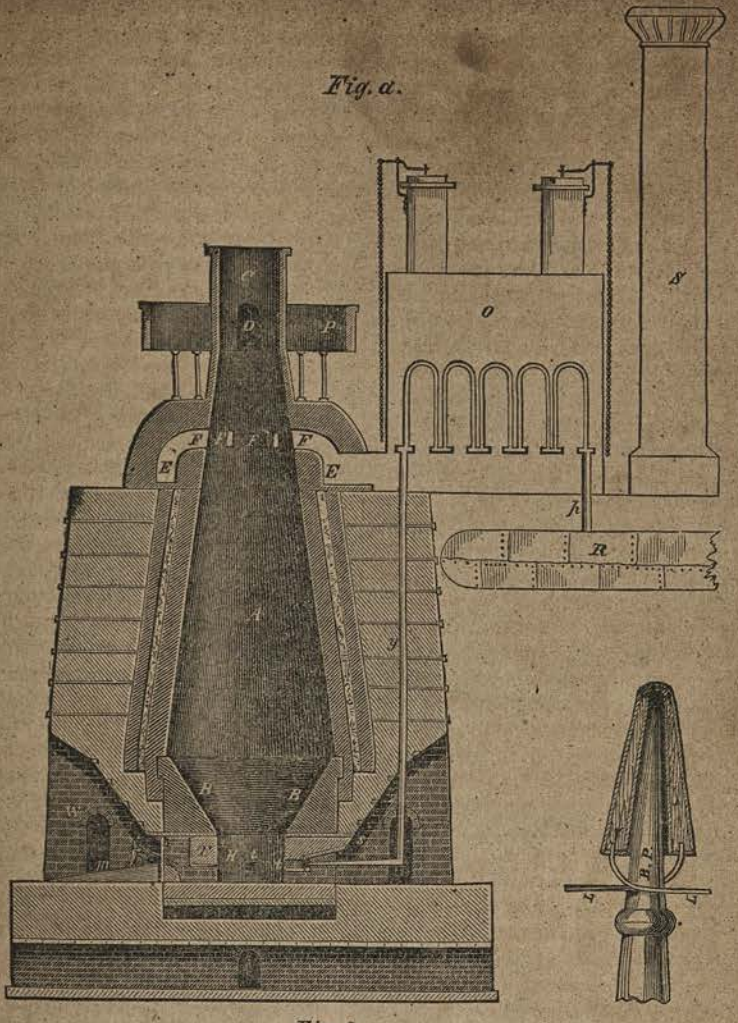
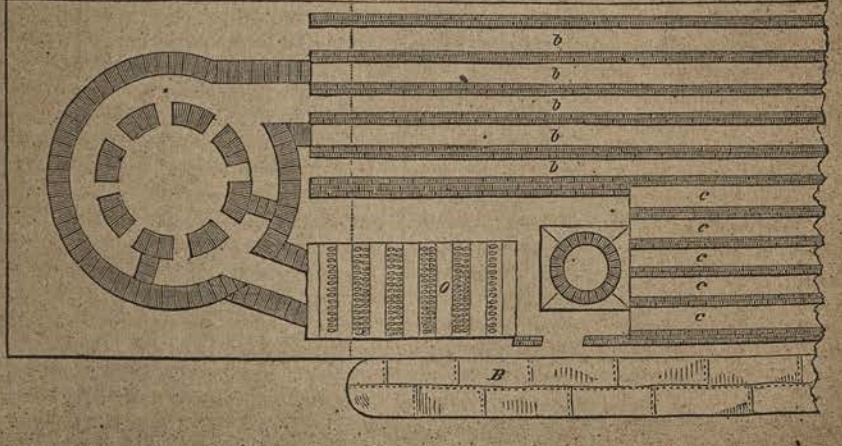


Fig. b.



Pig iron, as obtained from the blast furnaces, is classed as forge pig and foundry iron. The one kind is especially fitted for puddling, and not for recasting; while the other is suited for the latter purpose, and is kept for the use of the foundry. This is an establishment for remelting iron and casting it into moulded forms, as pipes, cannon, stoves, machinery, and the innumerable other articles which are made of cast iron. It is often connected with blast furnaces, but is also to be found in almost every large town, and in some the business is carried on upon a very extensive scale, the supplies of both crude iron and fuel being conveyed from a distance. The most extensive foundries in the United States are those of Albany and Troy, the great business of which is the manufacture of stoves. In the former city it has been stated that about 200,000 stoves are made every year. Cannon are cast at the foundries in Boston and Pittsburg, and other places in the United States. The property of cast iron to melt readily and take the form of the mould into which it is poured renders this of great value, especially for multiplying in great numbers the same object. But this kind of iron being brittle, it is not suited to a great variety of articles which require some strength, and which, on account of their complicated forms and great numbers, it would be very desirable to make by some cheaper method than by hammering them out of wrought iron. To meet this want a method was invented of removing from small articles in cast iron the carbon, which makes the distinction between this and malleable iron, and of doing this without affecting the shape of the article. As hitherto practised, the articles to be decarbonized, as the crooked mountings of harness, the elbows of pipes, and numerous other things, are placed upon shelves in an oven, and covered with some pulverized oxide of iron, as common iron rust. Here they are kept hot for ten days to two weeks, when it is found the oxygen of the iron rust and the carbon of the cast iron have disappeared—united together and gone off in the state of a gaseous mixture of the two elements—leaving the castings in a malleable state, and the rust in the form of a metallic incrustation adhering to them. Although the process is slow and imperfect, the metallic crust as it forms interposing itself between the carbon and oxygen remaining, and the results of a heat are often unsatisfactory, the business has been prosecuted with great success in many towns in New England and the middle states. But by the inventions of Prof. A. K. Eaton, of New York, its character now promises to be essentially modified. The first object was to find some oxide, the base of which was also volatile, so that when decomposed all of it would escape, leaving room for fresh oxide to reach the cast iron. The oxide of zinc was found to answer this purpose, especially when used in the form of the native carbonate of the oxide. This being substituted for the oxide of iron, the decarbonization was rapidly effected, from 18 to 24 hours being sufficient to accomplish what required by the other method 10 days to two weeks. The process, moreover, effected another result. The vapors of zinc were collected and condensed in water, and thus this metal was obtained from its ore. By another very recent discovery of the same chemist, it appears that carbonate of soda, or crude soda ash, has a property, scarcely ever before recognized, of removing carbon from cast iron which is immersed in the fused alkali; and as the sodium generated in the process tends to combine with and remove from the iron the phosphorus, sulphur, and silicon, which in very small quantity materially injure its quality, this method is likely to prove still more important than the other. It is applicable also to the production of steel from cast iron, as will be noticed in treating of this article.

WROUGHT IRON.

Of the various methods of producing wrought iron direct from the ore, the most simple and the one in most extensive use is that of the bloomary fire. It consists of a receptacle, open in front, of about three feet from front to back, two feet in width, and depth below the opening one and a half feet. A tuyere for the blast enters on one side at this height above the bottom, and is connected with the pipes for heating the blast, which are arranged in the wide chimney that completes the top of the structure. The receptacle is filled with rich ores, freed as much as possible from all foreign mixtures, and mixed with sufficient charcoal to effect their reduction. This being fired, the blast is let on, and as the mass becomes softened by the heat, it is stirred up by heavy ringers or iron pokers, and the particles of iron are brought together and made to cohere in one lump or loup. This is then taken out and immediately

placed under the forge hammer, or passed through the squeezer, by either of which processes it is freed from the cinder and oxide of iron, and converted into a bloom, an oblong block of wrought iron of convenient size for handling or for transportation. The process is not adapted for ores of less than sixty-five per cent. of iron, and even with these the waste is very great, two tons and a half being required to make one ton of blooms. The consumption of charcoal is about 250 bushels. Each fire can produce about one ton in twenty-four hours; or with rich magnetic ores in coarse particles, one hundred pounds per hour may be obtained. Two men are required to each fire, and their wages by contract are eleven dollars per ton of blooms. With ores costing nine dollars, and charcoal from fifteen to seventeen dollars for 250 bushels—rates which are common in northern New York—the cost of a ton of blooms is from thirty-five to thirty-seven dollars. The quality of the iron is better than the ores can be made to produce by other processes; for at the moderate heat employed, some of the foreign metallic bases present escape reduction, and do not combine with the iron, as they are likely to do in the high heat of the blast furnace. But on the other hand the quantity of iron lost in the cinder is large, and so is the consumption of fuel. The process is particularly adapted to thinly inhabited districts, where magnetic ores abound, water power can be had upon almost every stream, and charcoal is worth little more than the labor of preparing and hauling it to the works. A bloomary fire requires little capital to start it, and new ones can be added as fast as the business warrants the increase. As this declines, the fires may be stopped for a longer or shorter time without involving the serious losses occasioned by the interruption of the blast of the smelting furnace. The extent to which the business can be increased in any locality is limited by the necessary dependence of each fire upon two experienced workmen (in case it is run night and day), which is equivalent to the employment of two skilful men for every ton of iron made per day. Where such labor is not abundant, great difficulty may be experienced in keeping the works in operation. The great districts for bloomaries are the counties of Clinton and Essex, New York, northern New Jersey, and recently the iron district of Lake Superior. In 1850 there were no less than two hundred fires in the two counties named above, of which number twenty-one were in one establishment.

In order to reheat the blooms for hammering them into bars, a separate fire was formerly employed; but by a recent improvement the gaseous products of combustion that escape from the bloomary fire are conveyed into a reheating furnace, in which the blooms are placed, and into which the hot-air blast is blown through a large number of tuyeres, so as to introduce its oxygen throughout the partially consumed gaseous mixture. By this means an intense heat is generated, without extra expense of fuel, and two bloomary fires supply sufficient gases for one reheating furnace.

A great number of processes have been patented for making wrought iron direct from the ore, most of which are based on the general plan introduced by Mr. Clay, of Great Britain. The ore, pulverized and screened, is mixed with two-fifths of its weight of bituminous coal, and the whole is introduced into a side chamber connected with a puddling furnace. There being heated, and partially deoxidized by the reaction of the carbon of the coal, it is brought into a condition ready for being balled up into a loup in the puddling furnace, into which the charge is transferred. Renton's plan, which has been in use in New Jersey, is to introduce the finely pulverized ore, mixed with twenty per cent. of charcoal, into vertical fire-brick tubes, arranged over a puddling furnace and heated by its escape heat. These tubes are twelve feet long, and five by eighteen inches in section; open at top, and so contrived at bottom that the charge can be let out as desired into the puddling furnace. In Harvey's or Salter's process the ore, pulverized and mixed with charcoal, was spread upon an inclined shelf in the upper part of the chimney of the puddling furnace; and after being partially heated, it was pushed off on to a lower and hotter shelf; and so it was kept gradually moving down till it was at last delivered into the puddling furnace, new charges being introduced at the top to keep the charges full.

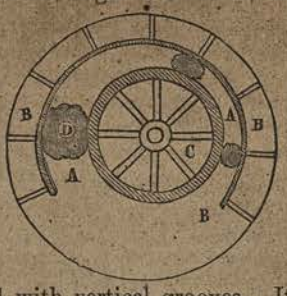
Puddling.—The great supplies of wrought iron are obtained from pig metal by the process called puddling. The principle of this operation is the removal of the carbon from the pig iron by exposing the melted metal to the action of the oxygen of the air, and causing it to escape in combination with

this in the form of carbonic acid gas. The furnaces employed are reverberatory; the fire, of bituminous coal, wood, peat, or anthracite, being at one end, and the flame from it playing over a bridge from which it impinges upon the roof of a long, low oven, and is reflected down upon the floor of this, where the metal to be melted is placed. By thus separating the fuel from the metal, this is kept free from any injurious mixtures which might be introduced with the former. The best fuels are those which give the most flame, and when anthracite is used it is necessary to increase the draught by means of a fan blower; and in the United States this is commonly employed with bituminous coals also. The puddling furnaces are either single or double. The former are only worked on one side, and have a hearth area of sixteen to twenty-four square feet; while the double furnaces have a hearth area of about forty feet, and are worked from two opposite sides. Fire brick is used in their construction, and the whole is incased in cast iron plates, which are securely bound together with bars of iron. The floor of the hearth is formed of cast iron plates, covered with pulverized cinder in sufficient quantity to make, when it is melted, a complete layer of two or three inches in thickness. Around the hearth are hollow boshes of cast iron, left open at the ends for the free circulation of air to prevent their being overheated. Sometimes the blast is passed through them, thus taking away a portion of the heat to be returned to the fire. The hearth occupies a depression of about six inches in depth below the sill of the working-door. When the bed of cinder has become hard by cooling, some iron scales or forge cinder are added to it, and usually some pulverized magnetic iron ore also. It is then ready for the cast iron, which may be either in pieces of the original pigs, or in plate metal, which is pig iron partially refined by melting it in a refinery fire, in which it is exposed for a time to a current of air, and then running it out into flat cakes, and chilling these with cold water. The metal is improved in quality by this preliminary operation, and where fuel is cheap it is advantageously practised. In Pennsylvania it is done in small furnaces, called run-out fires. The charge of a single puddling furnace is from 350 to 500 pounds; the double furnace is charged with twice as much. The pieces are all less than twenty-eight pounds each. Before being introduced they are economically heated in an oven in the chimney. After being placed on the hearth, the doors are tightly closed, and a brisk fire is kept up for about a quarter of an hour, until the pieces are at a bright red heat. Through the hole in the side-door the workman then places them by means of an iron bar in the best position for being uniformly heated to the temperature required. In less than half an hour the pieces are so softened, that they can be broken into fragments by the bar working through the same hole in the door. When they are just ready to melt, the fire is checked by closing the damper on the top of the chimney, and water is thrown in, a little at a time, to cool the charge; or pulverized iron ore, or iron scales, or cinder are used instead of water. The workman then begins to stir the pieces about, beating the fragments with his hook or bar, until they are all reduced to powder. The fire is then gradually increased by raising the damper and adding fuel, while the stirring of the metal is continued. In less than an hour from the beginning the iron commences to form soft, spongy lumps, which, if well worked at sufficiently high heat, adhere to each other, so that they may be collected into balls of any size. This is what is called "coming to nature." The making up of the iron into balls requires active work, which must be continued without cessation till the whole is converted into these globular masses of seventy to one hundred pounds weight each. The balls as they are made are laid up against the fire bridge to protect them from the oxidizing action of the flame, as well as to get them out of the way; and when all are ready the furnace is closed for a few minutes to give them a thorough heat. They are then taken out one by one, and dragged in tongs or upon a car to the hammer or squeezer, to be forged into blooms. The time consumed in the puddling for each heat is usually an hour and a half, but sometimes much longer. As soon as one charge is out another is introduced, and the furnace is kept in constant operation, thus avoiding the loss of fuel that would attend its cooling.

A method of puddling is much practised, which is called boiling. The furnace used for this purpose is like the puddling furnace, except that the hearth is deeper, in order to give capacity for a greater quantity of forge cinder, upon a large supply of which the operation depends. This is spread over the

bottom in sufficient quantity to form a layer 4 inches deep, and as it begins to cool, it is drawn up around the sides, so as to leave a depression in the centre. In this the iron is placed, and as soon as may be is melted down. The damper is then closed to keep the temperature uniform, and the iron and cinder are busily stirred; at the same time more cinder is thrown in—a handful at a time—till the contents begin to swell up and boil. This is owing to the formation of carbonic oxide from the carbon of the pig iron and the oxygen of the iron scales of the cinder, and as this gas rises it burns with a blue flame. Gradually the boiling subsides, by reason of the removal of the carbon, and the cinder settles down, leaving the iron in spongy masses, which would unite into one body if not worked over and broken up as in ordinary puddling. This being thoroughly done, it is then well heated and made up into balls for the hammer. The process requires more time, labor, and fuel than the other; but it produces better iron, and more of it from the same quantity of crude metal. Thus 95 per cent. is sometimes obtained from metal which, when treated by the other method, may yield only 80 per cent. The extent, however, to which the operation may be carried on is limited by the amount of cinder available, which is supplied wholly from the puddling furnaces.

The consumption of fuel in puddling is from 1,700 to 2,240 lbs. of anthracite or of bituminous coal to the ton of rough bars obtained. The waste of the metal is in great part made up, and sometimes wholly so, by the addition of rich ores to the charge. This plan was first adopted in the United States, and is now generally practised wherever such ores can be obtained. The cost of the labor employed in puddling is from $3.50 to $4 per ton. The forging of puddlers' balls into blooms is called shingling, and was formerly performed altogether under the forge hammer. This, however, is now very generally supplanted by the squeezer, of which there are two sorts—one a ponderous lever, the short arm of which, shaped like the upper jaw of a crocodile, opens and closes over a fixed lower jaw. The ball being placed between these is powerfully compressed, and being properly handled at the same time is made to receive the desired shape. A more perfect machine is the rotary squeezer invented by Mr. Henry Burden, of Troy. It consists of an upright cylinder of cast iron about 4 feet in diameter, the same height as the length of a bloom, and its face



serrated with vertical grooves. It is made to revolve within an elliptical shell, which is open on one side to receive the ball. As this is presented at the larger aperture on one side of the opening, it is drawn in by the revolution of the cylinder, and thoroughly squeezed, as it is rolled around between the two serrated faces. The space between these grows narrower by the slight eccentricity of the shell, and when the ball is brought round to the other side of the revolution of the cylinder and is there discharged, it is greatly reduced in diameter, and enlongated in the form of a cylindrical block.

The next process is to reduce this into rough bars. The bloom, without reheating, is taken directly to the roughing rolls, and passed between these; first through the largest space, and then successively through smaller and smaller grooves, until it is drawn out in the shape required. The iron is still very imperfect, being hard and brittle, with many flaws and imperfections. To convert it into merchantable iron, it is cut into short lengths by shears worked by machinery; and the pieces are made up into piles or faggots, which are placed upon the hearth of a "reheating furnace." This is made like a puddling furnace, with a very low roof, so designed that the space may be entirely occupied by the gaseous products of combustion to the exclusion of atmospheric air, the effect of which would be to oxidize and waste the metal, besides injuring its quality by introducing scales of the oxide. The hearth is made to slope toward the base of the chimney-flue at the back end, and being covered with pure silicious sand, the oxide of iron which forms combines with this, and flows down as a silicate of the protoxide of iron in a liquid cinder. When at a good welding heat the piles or faggots are taken out, and passed through the finishing rolls, which are of much superior construction to

the roughing rolls, their faces being smooth and polished, and the shape of the grooves made as perfect as possible, to give all the forms of iron required in merchant bars. From faggots thus made the iron is prepared for railroad bars, the peculiar forms of which require rolls of complicated designs.

The rolling mills of the United States, in operation in 1856, were as follows:—

No. of Mills.	States.	Product. Tons.
1	Maine	4,500
19	Massachusetts	55,292
2	Rhode Island	4,475
5	Connecticut	5,759
1	Vermont	500
13	New York	55,172
10	New Jersey	28,403
91	Pennsylvania	241,484
4	Delaware	2,211
13	Maryland	14,812
12	Virginia	26,355
1	North Carolina	215
3	South Carolina	1,210
1	Georgia	900
3	Tennessee	2,630
15	Ohio	30,980
7	Kentucky	16,865
1	Indiana	Unfinished.
1	Illinois	"
4	Missouri	4,420
2	Michigan	1,848

The mills making railroad iron at the same time were the following, producing the quantities given:—

	Tons of Rails.
The Bay State, South Boston	17,871
" Rensselaer, Troy, N. Y.	13,512
" Trenton, N. J., about	13,000
" Phœnixville, Pennsylvania	18,592
" Pottsville, Schuylkill Co., Penn	3,021
" Lackawanna, Luzerne Co., Penn	11,338
" Rough and Ready, Danville, Penn	5,259
" Montour, Danville, Penn	17,538
" Safe Harbor, Lancaster Co., Penn	7,347
" Mount Savage, Cumberland, Maryland	7,159
" Cambria, Cambria Co., Penn	13,206
" Brady's Bend, Armstrong Co., Penn	7,533
" Cosalo, Lawrence Co., Penn	0
" Washington, Wheeling, Va	2,355
" McNickle, Covington, Ky	1,976
" Newbury, near Cleveland, Ohio	0
" Railroad Mill, Cleveland, Ohio	0
" Wyandotte, near Detroit, Mich	1,848
" Chicago, Ill	0
" Indianapolis, Indiana	0
	141,555

About 1,000 tons in addition to the above were rolled at Pottsville, in the Palo Alto mill; making a total production of 142,555 tons of railroad iron, two-thirds of which were made in Pennsylvania.

SHEET IRON.—For making sheet iron the bars are gradually spread out, between smooth rolls, which are brought nearer together as the metal grows thinner. The Russians have a method of giving to sheet iron a beautifully polished surface, and a pliability and durability which no other people have been able to imitate. All attempts that have been made to learn the secret of this process have entirely failed, and the business remains a monopoly with the Russians. The nearest imitation of this iron is produced at Pittsburg, Pennsylvania, and several eastern establishments, by what is called Wood's process. This consists in rolling the common sheet at a certain temperature while it is covered with linseed oil. A very fine surface is thus produced, but the pliability and toughness of the Russian iron are wanting, even though the sheets are often annealed in close vessels, and the glaze and color are also inferior. Sheet iron is now extensively prepared for roofing, and other uses requiring exposure to the weather, by protecting its surface with a coating of zinc. This application is an American invention, having been discovered in 1827, by the late Prof. John W. Revere, of New York. In March, 1859, he exhibited, at a meeting of the Lyceum of Natural History, specimens of iron thus protected, which had been exposed for two years to the action of salt water without rusting. He recommended it as a means of protecting the iron fastenings of ships, and introduced the process into Great Britain. Sheets thus coated are known as galvanized iron, though the iron is now coated with zinc by other means as well as by the galvanic current. One method, that of Mallet, is to place the sheets, after they are well cleaned by acid and scrubbed with emery and sand, in a saturated solution of hydrochlorate of zinc and sulphate of ammonia; and after this in a bath composed of 202 parts of mercury and 1,292 of zinc, to every ton weight of which a pound of potassium or sodium is added. The compound fuses at 680° Fahrenheit, and the zinc is immediately deposited upon the iron surface. Another method is to stir the sheets in a bath of melted zinc, the surface of which is covered with sal ammoniac.

The use of heavy sheets or plates for building purposes is also a recent application of iron, that adds considerably to the demand for the metal. The plates are stiffened by the fluting, or corrugating, which they receive in a powerful machine, and may be protected by a coating of zinc. Their prep-

aration is largely carried on in Philadelphia; and in the same works a great variety of other articles of malleable iron, for domestic and other uses, are similarly protected with zinc, as window shutters, water and gas pipes, coal scuttles, chains for pumps, bolts for ships' use, hoop iron, and telegraph and other wire.

The production of the principal boiler-plate and sheet iron establishments of the United States are thus given for the year 1856:—

	Tons.
East of the Delaware there are but two mills, both of which are in Jersey City. Product in 1856	550
In E. Pennsylvania, on the Schuylkill and lower Susquehanna, 25 mills	21,218
Near Wilmington, Delaware, 3 mills	1,374
Between Wilmington and Baltimore, 7 mills	2,998
Pittsburg, Penn., 14 mills. Sheet iron, 6,437; boiler iron, 3,212; besides bars, rods, hoops, and nails	9,649
Sheet iron at the Sharon mill, Mercer Co. Penn.	500
Bloom mill, Portsmouth, S. Ohio, and Globe mill, Cincinnati, about	2,000
	38,289

A mill for boiler plate has been erected at St. Louis.

IRON WIRE.—The uses of iron wire have greatly increased within a few years past. The telegraph has created a large demand for it; and with the demand the manufacture has been so much improved, especially in this country, that the wire has been found applicable to many purposes for which brass or copper wire was before required. It is prepared from small rods, which are passed through a succession of holes, of decreasing sizes, made in steel plates, the wire being annealed as often as may be necessary to prevent its becoming brittle. In this branch the American manufacturers have attained the highest perfection. The iron prepared from our magnetic and specular ore is unequalled in the combined qualities of strength and flexibility, and is used almost exclusively for purposes in which these qualities are essential. But where stiffness combined with strength is more important, Swedish and Norwegian iron also are used. Much of the iron wire now made is almost as pliable as copper wire, while its strength is about 50 per cent. greater. In Worcester, Mass., a large contract has been satisfactorily filled for No. 10 wire, one of the conditions of which was that the wire, when cold, might be tightly wound around another wire of the same size without cracking or becoming rough on the surface. Such wire is an excellent material for ropes, and considerable American iron is already required for this use, especially for suspension bridges. Wires are also used for fences, and are ingeniously woven into ornamental patterns. The so-called "netting fence," thus made, can be rolled up like a carpet. For heavier railing and fences, as for the front yards of houses, for balconies, window guards, etc., iron bars and rods are now worked into ornamental open designs, by powerfully crimping them and weaving them together like wires.

NAILS.—Among the multitude of other important applications of malleable iron, that of nail making is particularly worthy of notice, as being in the machine branch of it—the preparation of cut nails—entirely an American process. Our advance in this department is ascribed to the great demand for nails among us in the construction of wooden houses. In England, even into the present century, nails were wrought only by hand, employing a large population. In the vicinity of Birmingham it was estimated that 60,000 persons were occupied wholly in nail making. Females and children, as well as men, worked in the shop, forging the nails upon anvils, from the "split iron rods" furnished for the purpose from the neighboring iron works. The contrast is very striking between their operations and those of the great establishments in Pennsylvania, consisting of the blast furnaces, in which the ores are converted into pig; of the puddling furnaces, in which this is made into wrought iron; of the rolling and slitting mills, by which the malleable iron is made into nail-plates; and of the nail machines, which cut up the plates and turn them into nails—all going on consecutively under the same roof, and not allowing time for the iron to cool until it is in the finished state, and single establishments producing more nails than the greater part of the workshops of Birmingham fifty years ago. Public attention was directed to machine-made nails as long ago as 1810, by a report of the secretary of the treasury, in which he referred to the success already attained in their manufacture in Massachusetts. "Twenty years ago," he states, "some men, now unknown, then in obscurity, began by cutting slices out of old hoops, and, by a common vice gripping these pieces, headed them with several strokes of the hammer. By progressive improvements, slitting mills were built, and the shears and the heading tools were perfected, yet much

labor and expense were requisite to make nails. In a little time, Jacob Perkins, Jonathan Ellis, and a few others, put into execution the thought of cutting and of heading nails by water; but being more intent upon their machinery than upon their pecuniary affairs, they were unable to prosecute the business. At different times other men have spent fortunes in improvements, and it may be said with truth that more than a million of dollars have been expended; but at length these joint efforts are crowned with complete success, and we are now able to manufacture, at about one-third of the expense that wrought nails can be manufactured for, nails which are superior to them for at least three-fourths of the purposes to which nails are applied, and for most of those purposes they are full as good. The machines made use of by Odiorne, those invented by Jonathan Ellis, and a few others, present very fine specimens of American genius." The report then describes the peculiar character of the cut nail—that it was used by northern carpenters without their having to bore a hole to prevent its splitting the wood; that it would penetrate harder wood than the wrought nail, etc. At that time, it states, there were twelve rolling and slitting mills in Massachusetts, chiefly employed in rolling nail plates, making nail rods, hoops, tires, sheet iron, and copper, and turning out about 3,500 tons, of which about 2,400 tons were cut up into nails and brads. From that time to the present the manufacture of nails by machinery has been a profitable branch of industry in the south-eastern part of Massachusetts, the iron and the coal being furnished from the middle Atlantic states, and the nails, in great part, finding a market at the south. The following table presents the number of nail mills in operation in 1856. The smaller establishments are gradually going out of the business, and this is becoming more concentrated in the coal and iron regions, thus saving the cost of transportation in these heavy articles. The manufacturers of New England, however, ingeniously divert a part of their operations to the production of smaller articles, with which the cost of transportation is a less item in proportion to their value, such as tacks, rivets, screws, butts, wire, and numerous finished articles, the value of which consists more in the labor performed upon them and in the use of ingenious machinery than in the cost of the crude materials employed.

NAIL FACTORIES IN THE UNITED STATES, AND THEIR PRODUCTION IN 1856.

	Tons.
In south New England, 12 mills, nails principally	25,000
Troy, New York	4,000
Rockaway, Boonton, New Jersey, nails and spikes	8,250
Southern New Jersey	4,167
On the Schuylkill, 5 mills, about	9,000
On the lower Susquehanna, 2 mills, about	2,600
Middle Pennsylvania, 2 mills, about	2,000
Maryland, 2 mills	2,155
Richmond, 1 mill	1,075
Pittsburg, 14 mills, nails, spikes, rivets, tacks	14,195
Wheeling, 2 mills	6,465
Ironton, southern Ohio, 1 mill	775
Mahoning Co., N. E. Ohio, 1 mill	380
Buffalo	1,400
Total	81,462

The number of nail machines employed in these mills was 2,645.

A great variety of machines have been devised for nail making, very ingenious in their designs, and all too complicated for description. The iron is rolled out into bars for this manufacture, of 10 or 12 feet in length, and wide enough to make three or more strips, each one of which is as wide as the length of the nail it is to make. The cutting of these strips from the wider bars is the special work of the slitting mill, which is, in fact, but a branch of the rolling operation, and carried on in conjunction with it. The slitting machine consists of a pair of rolls, one above the other, each having 5 or 6 steel disks upon its axis, set as far apart as the width required for the nail-rod. Those upon one roll interlock with those upon the other, so that when the wide bar is introduced it is pressed into the grooves above and below, and cut into as many strips as there are spaces between the disks. This work is done with wonderful rapidity, several bars being passed through at once. In the nail factory each nail-making machine works upon one of these strips, or nail-rods, at a time, first clipping off a piece from the end presented to it, and immediately another, as the flat rod is turned over and the end is again presented to the cutter. The reason of turning it over for each successive cut is because the piece cut off for the nail is tapering, in order to make it a little wider at the end intended for the head than at the other, and thus, making the wider cut on alternate sides of the rod, this is regularly worked up into pieces of the proper shape. In the older operations a workman always sat in front of each machine, holding the

rod and turning it over with every clip; but by a modern improvement this work is also done by mechanical contrivance. Each piece, as fast as it is clipped off, disappears in the machine. There it is seized between powerful jaws, and the head is pressed up from the large end by the short, powerful motion imparted to the piece of apparatus called the header. As it is released, it slides down and drops upon the floor, or in a vessel placed to receive the nails.

Machinery has been applied in the United States to the manufacture of horse-shoe nails, according to a number of patented plans. Of these, the most successful is probably that invented about the year 1848, by Mr. L. G. Reynolds, of Providence; also the inventor of the solid-headed pin. The form of this nail could not be given as in ordinary cut nails by the cutter, but the sides required to be pressed as well as the head. This involved the use of movable plates of suitable figure; and as it was found that the nails could not be shaped except when the metal was softened by heat, the plates must necessarily be of the hardest steel, and protected as effectually as possible from the effects of constant working of heated iron. These difficulties were fully overcome, and the nails, after being turned out, were toughened by annealing, giving them all the excellent qualities of hand-made nails, with the advantage of perfect uniformity of size, so that one nail answers as well as another for the holes in the horse-shoes. They are, moreover, made with great rapidity, each machine producing half a ton of nails in 12 hours. The process has been taken to Europe, and is there in successful operation. Spikes, also, have been made and headed in similar machines; and among all small articles in iron, none, perhaps, has proved so profitable to the inventor as the hook-headed spike, used for holding down, by its projecting head, the edge of the iron rails to the sill. This was the invention of Mr. Henry Burden, of Troy, whose machines for wrought-iron spikes and for horse-shoes have also proved very successful. By the latter, perfect shoes are turned out at the rate of 60 in a minute. This process has been introduced in most of the European countries.

STEEL.

As already remarked, steel differs in composition from metallic iron only by containing from ½ to 1½ per cent. of carbon, and from cast-iron by the latter containing a larger proportion of carbon, which may amount to 5.5 per cent. To readily convert these varieties into each other is an object of no small importance, for their properties are so entirely distinct, that they really serve the purposes of three different metals. Steel is particularly valuable for its extreme hardness, fine grain, and compact texture, which admits of its receiving a high polish. It is the most elastic of metals, and much less liable to rust than iron. It has the peculiar property of assuming different degrees of hardness, according to the rapidity with which it is chilled when heated; and it may be melted and run into moulds like cast iron, and the ingots thus prepared may be hammered, rolled, and forged into shapes like wrought iron; and these may finally be tempered to any degree of hardness desired. Differing so little in composition from metallic iron and from cast iron, and being so universally in demand for a multitude of uses, it would seem that it ought to be produced as cheaply as one or the other of the varieties, between which its composition places it. But this is far from being the case. While pig iron is worth only $20 to $30 per ton, and bar iron $60 to $90, cast steel in bars is worth from $250 to $300 per ton. This is chiefly owing to the difficulty of procuring in large quantities steel of uniform character, which the consumers of the article can purchase with perfect confidence that it is what they require and have been accustomed to use. The English boast, with good reason, of the position they occupy in this manufacture, which is almost a monopoly of the steel trade of the whole world. Though producing themselves little or no iron fit for making alone the best steel, they have imported enough of the Swedish and Norwegian bar iron to insure a good quality, and have been especially cautious to render this as uniform as possible. Their method of manufacture is to introduce carbon into the wrought iron by what is called the cementing process. On the continent of Europe steel is made to some extent, in Silesia and Styria, by removing from cast iron enough of its carbon to leave the proper proportion for steel, and then melting the product and casting it into ingot moulds. But this cheaper method does not appear to have been taken up in Great Britain. In the United States several processes are in operation, two of which are peculiarly American. The ce-

menting method, as conducted in England, has been longest known, and will be first described. The cementing furnace is a sort of oven, furnished with troughs or shelves, upon which charcoal dust is laid for receiving the bars. These are placed edgewise in the charcoal, half an inch apart, and the spaces are filled in with more sifted coal. Enough is added to cover the bars, and upon this a second tier is laid in the same way, and so on till the trough is filled with several tons of iron, all of which is perfectly excluded from the air. The trough being secured with others in the oven, a fire is started under them. In about six days the bars have absorbed enough carbon to acquire the properties of the softer kinds of steel, such as are used for saws and springs. In a day or two longer it answers for cutting instruments, and some time after this it gains in hardness, so as to be fitted for cold chisels, for drills such as miners use, etc. Its character is ascertained at any time by drawing out one of the bars. After the change is effected the fire is extinguished, and about a week is allowed for the furnace and its contents to cool. When at last the bars are obtained, their surface is found to be covered with blisters, whence the steel is called blistered steel. The fibrous texture of the iron has given place to a granular structure, but is so irregular and uneven that the metal requires further treatment to perfect it. To make the English shear-steel, so called from its being originally employed for shears used in sheep-shearing, the bars are cut into lengths of a foot and a half, and a number of these are bound together to make a faggot. This is brought to a welding heat, and drawn down first under a forge-hammer, and then under the tilt-hammer. This weighs from 150 to 200 pounds, and strikes from 150 to 360 strokes a minute. The rapidity of the work keeps the steel at a glowing heat, and it is soon fashioned into a dense bar of smooth surface, susceptible of a polish, and suited for the manufacture of cutting instruments. Sometimes it is cut into pieces to be refaggoted, and drawn down again into bars, which are then called double-shear.

Cast steel is a still more dense and perfect variety. It is prepared by melting, in large crucibles, blistered steel broken into small pieces, and pouring the metal into moulds. These are then worked into shapes by the forge hammer and the rolls.

The American methods of making steel were discovered by Prof. A. K. Eaton, of New York, and the one now employed by the Damascus Steel Company was practically demonstrated by him in Rochester and its vicinity in 1851 and 1852. This consists in carbonizing and melting malleable iron in crucibles at one operation, by introducing into the pot with the pieces of iron a carbonaceous salt, such as the ferro-cyanide of potassium, either alone or in combination with charcoal powder. At an intense heat this salt rapidly carbonizes the iron, which thus first becomes steel, then fuses, and is poured into moulds. The quantity of the salt employed is proportional to the quantity of the iron and the quality of the steel required. The operation is successfully carried on in different establishments in New Jersey, New York, and Pennsylvania, and cast steel of the very best quality is produced at less expense than the article has ever before cost in this country. For bar steel, according to the prospectus of the company, the best charcoal-made iron is employed, costing $85 per ton, and this, together with the coal used for fuel, the chemical materials, the melting, crucibles, and hammering, make the whole cost about $142 per ton, while that of the imported article is $300 or more. The great difficulty in the process is to obtain suitable crucibles for withstanding the intense heat required to melt the charge of 60 lbs. of malleable iron. Those in use are blue-pots, costing $1.60 each. Though made of the best of plumbago, they stand only two or three meltings.

The other process, which is just now introduced into practice, is based upon the property of carbonate of soda to remove from cast iron the carbon it contains, when the metal is kept for a few hours in a bath of the melted alkali. The decarbonizing effect is in part due to the action of the oxygen of the alkaline base, which is given up to the carbon of highly heated cast iron, but principally to the decomposition of the combined carbonic acid, which gives to the carbon one of its atoms of oxygen, and is resolved into carbonic oxide. This property of soda was discovered by Prof. Eaton in 1856, but the fact that the carbonated or bicarbonated alkalies act principally by virtue of their carbonic acid, was only recently recognized and made practically available by him. The action of soda or its carbonates is not limited to the removal of the excess of carbon in cast iron. It combines with and removes those impurities which would prove

fatal to the quality of the steel if remaining in it, as sulphur, phosphorus, and silicon; and the method thus admits of the use of crude irons, such as could never be applied to this manufacture by any other mode. The cast iron, in the form of thin plates, having been kept at a bright red heat in the bath of melted carbonate for a sufficient time, which is determined by occasionally taking out and testing some of the pieces, is transferred to the crucible, and is then melted and poured into moulds, as in the ordinary method of making cast steel. The crucibles, not being subjected to greater heat than is required for melting cast steel, endure much longer than when employed for melting wrought iron in the carbonizing process; thus a great saving is effected in the expense of the conversion; and this economy is still further increased by the use of a crude material, costing only from $20 to $30 per ton, in place of the superior qualities of wrought iron, worth $85 per ton. So great, indeed, is the saving, that the cost of the cast steel, when obtained in ingots, is found not to exceed the cost of the malleable iron employed in the other process.

STATISTICS.—The records of the production of iron of the United States are very incomplete up to the year 1854. Even the census returns are highly defective, as they often make no distinction between iron made from the ore and the products of the secondary operations of remelting and puddling. The first systematic attempts to obtain complete accounts of the business, as conducted in Pennsylvania, were made in 1850 by the Association of Iron Manufacturers, organized in Philadelphia. Mr. Charles E. Smith collected the returns, and published them in a small volume, together with other papers relating to the manufacture. In 1856 the association, through their secretary, Mr. J. P. Lesley, and their treasurer, Mr. C. E. Smith, obtained full returns from 832 blast furnaces, 488 forges, and 225 rolling mills in the United States, besides others in Canada, exhibiting their operations for the preceding three years. Some of these results are presented in the following tables:—

NO 1.—TABLE OF IRON WORKS IN OPERATION AND ABANDONED IN 1858.

	Anthracite Furnaces.	Charcoal and Coke Furnaces.	Abandoned Furnaces.	Bloomary Forges.	Abandoned Bloomaries.	Refinery Forges.	Abandoned Refineries.	Rolling Mills.	Abandoned.
Maine	..	1	..	..	..	..	..	1	..
New Hampshire	..	1	..	..	..	1	..	..	..
Vermont	..	5	..	5	..	..	..	1	..
Massachusetts	3	7	..	..	..	5	1	19	..
Rhode Island	..	..	..	..	..	..	..	2	..
Connecticut	1	14	..	..	..	6	..	5	..
New York	14	29	6	42	1	3	2	11	5
New Jersey	4	6	12	48	29	2	..	10	1
Pennsylvania	93	150	102	1	3	110	44	91	5
Delaware	..	..	1	..	..	..	..	4	..
Maryland	6	24	7	..	..	..	..	13	..
Virginia	..	39	56	..	..	43	..	12	..
North Carolina	..	3	3	36	..	..	..	1	..
South Carolina	..	4	4	2	..	..	..	3	1
Georgia	..	7	1	4	..	..	..	2	..
Alabama	..	3	1	14	..	..	..	..	..
Tennessee	..	41	33	50	2	9	3	3	..
Kentucky	..	30	17	..	..	4	9	8	2
Ohio	..	54	26	..	..	..	5	15	..
Indiana	..	2	3	..	..	..	..	1	..
Illinois	..	2	..	..	..	..	..	1	..
Michigan	..	7	..	3	..	..	..	2	..
Wisconsin	..	3	..	..	..	..	..	..	..
Missouri	..	7	..	..	..	3	..	5	..
Arkansas	..	..	..	1	..	..	..	..	1
Total	121	439	272	206	35	186	64	210	15

In working order, 560 Furnaces, 389 Forges, 210 Rolling Mills. Total, 1,159
Abandoned, 272 " 99 " 15 " " 386

In all, 832 " 488 " 225 " " 1,545

The production of the blast furnaces in the different iron districts for the years 1854, 1855, and 1856, is exhibited in Table No. 2; their arrangement being according to the fuel employed and the quantities of iron produced in each district in 1856:—

TABLE NO. 2.—PRODUCTION OF PIG IRON.

Fuel.	District.	1854.		1855.		1856.	
Anthracite	Pennsylvania	208,603		255,326		306,972	
"	Out of Pennsylvania	99,007		87,779		87,537	
Charcoal and Coke	S. Ohio	56,081	79,010	47,982	64,162	70,455	92,116
" " "	E. Kentucky	22,929		16,180		21,661	
" " "	W. Pennsylvania	78,927	90,216	59,388	69,314	59,597	76,653
" " "	N. Ohio	11,289		9,926		17,056	
" " "	E. Pennsylvania	62,724		60,596		52,775	
Charcoal	W. Tennessee	37,918		33,683		32,162	
"	W. Kentucky	12,236	53,054	13,664	50,347	14,902	50,664
"	S. Indiana	1,400		1,500		1,800	
"	S. Illinois	1,500		1,500		1,800	
Charcoal and Coke	S. W. Pennsylvania	11,052	12,982	18,217	20,559	29,400	30,867
" " "	N. W. Virginia	1,930		2,342		1,467	
" " "	Maryland	36,658		35,309		30,998	
Charcoal	E. of the Hudson	30,420		32,826		29,937	
"	N. and W. New York	19,197		19,736		18,847	
"	Missouri	7,591		10,181		10,138	
"	S. New York and N. New Jersey	13,435		7,901		5,688	
"	E. and Middle Virginia	5,880		6,926		5,736	
"	North and South Carolina	1,820		1,830		1,956	
"	Georgia	2,391	6,056	2,715	6,061	2,807	7,694
"	E. Tennessee and Alabama	1,845		1,516		2,931	
"	Michigan	990		950		3,078	6,178
"	Wisconsin					2,500	
Total production of pig iron in the United States	Tons	724,833		728,973		812,917	

TABLE NO. 3.—DISTRIBUTION OF THE FURNACES BY STATES.

I. ANTHRACITE FURNACES.

No.	States.	Product. Tons.
3	Massachusetts	4,443
1	Connecticut	0
14	New York	47,257
4	New Jersey	26,117
93	Pennsylvania	306,972
6	Maryland	10,720
121		394,509

II. COKE FURNACES.

21	Pennsylvania	39,953
3	Maryland	4,528
24		44,481

III. RAW BITUMINOUS COAL FURNACES.

6	Pennsylvania	8,417
13	Ohio	16,656
19		25,073

IV. CHARCOAL FURNACES.

1	Maine	2,100
1	New Hampshire	0
5	Vermont	2,420
7	Massachusetts	8,564
14	Connecticut	12,876
29	New York	21,774
6	New Jersey	2,100
143	Pennsylvania	96,154
21	Maryland	26,470
39	Virginia	14,828
3	North Carolina	450
4	South Carolina	1,506
7	Georgia	2,807
3	Alabama	1,495
41	Tennessee	28,476
30	Kentucky	36,563
41	Ohio	70,355
2	Indiana	1,800
2	Illinois	1,900
7	Missouri	10,138
3	Wisconsin	2,500
7	Michigan	3,678
416		348,854

	No. of Furnaces.	Tons.
Anthracite, as above	121	394,509
Coke, "	24	44,481
Raw Coal, "	19	25,073
Charcoal, "	416	348,854
Total pig	580	812,917

TABLE NO. 4.—PRODUCT OF WROUGHT IRON DIRECT FROM THE ORE. 1856.

Bloomaries.	States.	Product. Tons.
5	Vermont	1,650
42	New York	18,710
48	New Jersey	4,487
36	North Carolina	1,182
2	South Carolina	640
4	Georgia	40
14	Alabama	252
50	Tennessee	1,222
3	Michigan	450
204		28,633
Pig iron as above		812,917
Grand total production of iron from the ore in 1856		841,550

In addition to this amount, the importations for the year 1856 of iron designed for manufacture are estimated at 363,998 tons, consisting of Scotch pig, 55,403 tons; rolled and hammered iron, 298,275 tons; and scraps, 10,320 tons; and if to this be added for old rails reworked, 100,000 tons, and for scrap, 25,000 tons, the total amount of iron entering into domestic consumption was 1,330,548 tons. The importation of railroad iron not included in the above was 167,400 tons. The proportion of foreign iron introduced into the general consumption, not including rails, was about 30 per cent.

The value of the immediate products of the manufacture of domestic iron is thus given at the prices current in 1856:—

Foundry pig	302,154 tons	*a* $27,		$8,158,158
Foundry cold-blast charcoal iron for car wheels, &c.	35,000 "	*a* 35,		1,225,000
Rails	142,555 "	*a* 63,		8,980,965
Boiler and sheet	38,639 "	*a* 120,		4,636,680
Nails	81,462 "	*a* 84,		6,842,808
Bar, rod, hoop, and band	235,425 "	*a* 65,		15,302,625
Hammered iron	21,000 "	*a* 125,		2,625,000
Total				$47,771,236

Mr. Smith presents the following conclusion to the "Statistical Report of the Iron Manufacture:" "The great facts demonstrated are, that we have nearly 1,200 efficient works in the Union; that these produce annually about 850,000 tons of iron, the value of which in an ordinary year is 850,000,000; of this amount the portion expended for labor alone is about $35,000,000."

Since 1856 no attempts have been made to collect the statistics of the iron business of the United States, and consequently but a very general statement can be given of the changes which have taken place. The total annual production has probably not varied much from 800,000 tons—exceeding rather than falling short of this amount. In the Lehigh valley the business is rapidly increasing, while the charcoal iron manufacture in different parts of the country is steadily diminishing. In the vicinity of Baltimore only one furnace was in operation in November, 1860; and besides another at Texas, in Baltimore county, and one of the bog ore furnaces on the eastern shore, it is believed all the rest, including those in the bituminous coal region, were out of blast. The business, however, in general is in a sound condition, and great improvements have been made in diminishing the cost of the manufacture, by means of more care in the superintendence and by reducing the general expenses and the number of hands employed to the ton of iron produced. Several new rolling mills are about going into operation; one at Allentown, in Pennsylvania, and one at Elmira, New York.

The annual consumption of iron has of late years been increasing throughout the world with extraordinary rapidity—a fact which is strikingly shown by the increase of production in Great Britain, which in 1818 was estimated at 300,000 tons, and in 1855 at 4,399,836 tons. The rate of increase far exceeds that of the increase of population, and is due to the new applications of iron in the arts and to the constantly increasing demands of a rapidly advancing civilization for the new conveniences and comforts it affords. Railroads alone consume about one-third of all the iron made. It is an interesting consideration, should this increasing demand continue for years to come, from what sources are the enormous supplies to be furnished. The author of the paper on the "Statistics and Geography of the Production of Iron," already referred to, on the basis of a production doubling in 20 years, instead of 10 to 12 years, as has been the case in Great Britain since 1824, estimates that the make for 1875 should be 14,000,000 tons, for 1895, 28,000,000 tons, and so on. Already the enormous demand has greatly increased the cost of coal and iron ores in Great Britain, and this being attended with a rise in the value of labor, the cost of iron per ton is considerably greater than it was ten years ago; thus indicating that, although the limit of her capacity of production may not yet by any means be attained, the cost of iron is rising in the face of increased demand; and if this continues, while the development of the resources of the United States is tending to reduce the cost of the manufacture, the business in the two countries must, before many years, stand on the same footing. From the accounts in the preceding pages of the munificent supplies of ores with which this country is provided, it is apparent that her capacity of production is unlimited, and that however great the demand may prove, her resources will be fully equal to meet it for any period; and it may be added, that it is the only country of which this can be affirmed. There is, therefore, every reason to expect that the development of her iron mines will be pushed forward with constantly increasing energy, and that the time is not far distant when many of the great repositories of ores we have described—now almost untouched—will be the seats of an active industry and centres of a thriving population, supported by the home markets they will create. The great valley of the west, when filled with the population it is capable of supporting, and intersected in every direction with the vast system of railroads, of which the present lines form but the mere outlines, will itself require more iron than the world now produces, and the transportation of large portions of this from the great iron regions of northern Michigan and Wisconsin, and of

coal back to the mines, will sustain larger lines of transportation than have ever yet been employed in conveying to their markets the most important products of the country. The importation of foreign iron—already falling off in proportion to the increased consumption—must, before many years, cease, and be succeeded by exports for the supplies of other nations less bountifully provided for in this respect than the United States and Great Britain.

CHAPTER II.

COPPER.

THE early attempts to work copper mines in the United States have already been alluded to in the introductory remarks to the department of this work relating to mining industry. The ores of this metal are widely distributed throughout the country, and in almost every one of the states have been found in quantities that encouraged their exploration—in the great majority of cases to the loss of those interested. The metal is met with in all the New England states, but only those localities need be named which have at times been looked upon as important.

Copper occurs in a native or metallic state, and also in a variety of ores, or combinations of the metal with other substances. In these forms the metallic appearance is lost, and the metal is obtained by different metallurgical operations, an account of some of which will be presented in the course of this chapter. Until the discovery of the Lake Superior mines, native copper, from its scarcity, was regarded rather as a curiosity than as an important source of supply. The workable ores were chiefly pyritous copper, vitreous copper, variegated copper, the red oxide, the green carbonate or malachite, and chrysocolla. The first named, though containing the least proportion of copper, has furnished more of the metal than all the other ores together, and is the chief dependence of most of the mines. It is a double sulphuret of copper and iron, of bright yellow color, and consists, when pure, of about 34 per cent. of copper, 35 of sulphur, and 30 of iron. But the ore is always intermixed with quartz or other earthy minerals, by which its richness is greatly reduced. As brought out from the mine it may not contain more than 1 per cent. of copper, and when freed as far as practicable from foreign substances by the mechanical processes of assorting, crushing, washing, jigging, etc., and brought up to a percentage of 6 or 7 of copper, it is in Cornwall a merchantable ore, and the mine producing in large quantity the poor material from which it is obtained may be a profitable one. Vitreous copper, known also as copper glance, and sulphuret of copper, is a lead gray ore, very soft, and contains 79.8 per cent. of copper, united with 20.2 per cent. of sulphur. It is not often found in large quantity. Variegated or purple copper is distinguished by its various shades of color and brittle texture. It yields, when pure, from 56 to 63 per cent. of copper, 21 to 28 of sulphur, and 7 to 14 of iron. The red oxide is a beautiful ore of ruby red color, and consists of 88.8 per cent. of copper and 11.2 per cent. of oxygen. It is rarely found in sufficient quantity to add much to the products of the mines. Green malachite is a highly ornamental stone, of richly variegated shades of green, famous as the material of costly vases, tables, etc., manufactured in Siberia for the Russian government. It is always met with in copper mines, especially near the surface, but rarely in large or handsome masses. It consists of copper 57.5, oxygen 14.4, carbonic acid 19.9, and water 8.2 per cent. Chrysocolla is a combination of oxide of copper and silica, of greenish shades, and is met with as an incrustation upon other copper ores. It often closely resembles the malachite in appearance. It contains about 36 per cent. of copper.

The first mines worked in the United States were peculiar for the rich character of their ores. These were, in great part, vitreous and variegated copper, with some malachite, and were found in beds, strings, and bunches in the red sandstone formation, especially along its line of contact with the gneiss and granitic rocks in Connecticut, and with the trap rocks in New Jersey. The mine at Simsbury, in Connecticut, furnished a considerable amount of such ores from the year 1709 till it was purchased, about the middle of the last century, by the state, from which time it was occupied for sixty years as a prison, and worked by the convicts; not, however, to much profit. In 1830 it came into possession of a company, but was only worked for a short time afterward. On the same geological range, but lying chiefly in the gneiss rocks, the most productive of these mines was opened in

1836, in Bristol, Conn. It was vigorously worked from 1847 to 1857, and produced larger amounts of rich vitreous and pyritous ores than have been obtained from any other mine in the United States. No expense was spared in prosecuting the mining, and in furnishing the most efficient machinery for dressing the ores. It is stated that full 1,800 tons of ore were sent to market, which produced over $200,000, the yield ranging from 18 to 50 per cent. of copper. The mine was finally abandoned in 1857.

The New Jersey mines have all failed, from insufficient supply of the ores. The Schuyler mine, at Belleville, produced rich vitreous copper and chrysocolla, disseminated through a stratum of light brown sandstone, of 20 to 30 feet in thickness, and dipping at an angle of 12°. During the periods of its being worked in the last century, the excavations reached the depth of 200 feet, and were carried to great distances on the course of the metalliferous stratum. The mine was then so highly valued that an offer of £500,000, made for it by an English company, was refused by the proprietor, Mr. Schuyler. In 1857–58 attempts were made by a New York company to work the mine again, but the enterprise soon failed. Among the other mines which have been worked to considerable extent in New Jersey are the Flemington mine, which resembled in the character of its ore the Schuyler mine, and the Bridgewater mine, near Somerville, at which native copper in some quantity was found in the last century; two pieces met with in 1754 weighing together, it was reported, 1,900 lbs. A mine near New Brunswick also furnished many lumps of native copper, and thin sheets of the metal were found included in the sandstone. At different times this mine has been thoroughly explored, to the loss of those engaged in the enterprise. In Somerset county, the Franklin mine, near Griggstown, has been worked to the depth of 100 feet. Carbonate and red oxide of copper were found in the shales near the trap, but not in quantity sufficient to pay expenses. In Pennsylvania, near the Schuylkill river, in Montgomery and Chester counties, many mines have been worked for copper and lead at the junction of the red sandstone and gneiss. Those veins included wholly in the shales of the red sandstone group were found to produce copper chiefly, while those in the gneiss were productive in lead ores. At the Perkiomen and Ecton mines—both upon the same lode—extensive mining operations have been carried on; a shaft upon the latter having reached in 1853 the depth of 396 feet. The sales of copper ores during the three years the mines were actively worked amounted to over $40,500; but the product was not sufficient to meet the expenditures.

The mines in Frederick county, Maryland, in the neighborhood of Liberty, were near the red sandstone formation, though included in argillaceous and talcose slates. A number of them have been worked at different times up to the year 1853, when they were finally given up as unprofitable.

A more newly discovered and richer copper district in Maryland is near Sykesville, on the Baltimore and Ohio railroad, 32 miles from Baltimore, in a region of micaceous, talcose, and chloritic slates. A large bed of specular iron ore lying between the slates was found to contain, at some depth below the surface, carbonates and silicates of copper, and still further down copper pyrites. In the twelve months preceding April 1, 1857, 300 tons had been mined and sent to market, the value of which was $17,896.92, and the mine was reported as improving. The ore sent to the smelting works at Baltimore, in December of that year, yielded 16.03 per cent. of copper. Within seven miles of Baltimore the Bare Hill mine has produced considerable copper, associated with the chromic iron of that region.

Like the last two named, all the other localities of copper ores of any importance along the Appalachian chain and east of it are remote from the range of the red sandstone, and belong to older rock formations. In the granites of New Hampshire, pyritous copper has been found in many places, but has nowhere been mined to any extent. In Vermont, mining operations have been carried on to some extent upon a large and very promising lode of pyritous copper, which is traced several miles through Vershire and Corinth. At Strafford, pyritous ores were worked in 1829 and afterward, both for copperas and copper. In New York, excellent pyritous ores were produced at the Ulster lead mine in 1853. Among other sales of similar qualities of ore, one lot of 50 tons produced 24.3 per cent. of copper.

In Virginia, rich ores of red oxide of copper, associated with native copper and pyritous copper, are found in the metamorphic slates at Manasses Gap, and also in many other places further south along the Blue

Ridge. The very promising appearance of the ores, and their numerous localities, would encourage one to believe that this will prove to be a copper region, were it not that, when explored, the ores do not seem to lie in any regular form of vein. In the southern part of the state, in Carroll, Floyd, and Grayson counties, copper was discovered in 1852, and mines were soon after opened in a district of metamorphic slates, near their junction with the lower silurian limestones. The copper was met with in the form of pyritous ore, red oxide, and black copper, beneath large outcropping masses of hematite iron ore, or gossan. Some of the shipments are said to have yielded over 20 per cent. of copper. The amount of ores sent east, over the Virginia and Tennessee railroad, in 1855, was 1,931,403 lbs.; in 1856, 1,972,834 lbs.; and in the nine months ending June 30, 1857, 1,085,997 lbs.; 1858, 688,418 lbs.; 1859, 1,151,132 lbs.; and 1860, 2,679,673 lbs. Copper ores are very generally met with in the gold mines of this state, and further south, but the only one of them that has been worked expressly for copper is that of the North Carolina Copper Company, in Guilford county. From this a considerable amount of pyritous copper ores were sent to the north in 1852 and 1853.

In Tennessee, an important copper region lies along the southern line of Polk county, and extends into Gilmer county, Georgia. The ore was first found in 1847, associated with masses of hematite iron ores, which formed great outcropping ledges, traceable for miles from south-west to north-east along the range of the micaceous and talcose slates. An examination of the ores, made to ascertain the cause of their working badly in the furnace, was the means of corroborating or giving importance to the discovery of the copper. In 1851 copper mining was commenced, and afterward prosecuted with great activity by a number of companies. The ore was found in seven or eight parallel lodes of the ferruginous matters, all within a belt of a mile in width. At the surface there was no appearance of it, but as the explorations reached the depth of seventy-five or one hundred feet below the surface of the hills, it was met with in various forms, resulting from the decomposition of pyritous copper, and much mixed with the ochreous matters derived from a similar source. In a soft black mass, easily worked by the pick, and of extraordinary dimensions, were found intermixed different oxides and other ores of copper, yielding various proportions of metal, and much of it producing 20 per cent. and more, fit to be barrelled up at once for transportation. This ore spread out in a sheet, varying in width at the different mines; at the Eureka mine it was 50 feet wide, and at the Hiwassee 45 feet, while at the Isabella mine the excavations have been extended between two walls 250 feet apart. In depth this ore is limited to a few feet only, except as it forms bunches running up into the gossan or ochreous ores. Below the black ore is the undecomposed lode, consisting of quartz, more or less charged with pyritous copper, red oxide, green carbonate, and gray sulphuret of copper; and it is upon these the permanent success of the mines must depend. About 14 mining companies have been engaged in this district, and the production of the most successful of them was as follows, up to the year 1858: Isabella, 2,500 tons; Calloway, 200; Mary's, 1,500; Polk county, 2,100; Tennessee, 2,200; Hiwassee, 2,500; Hancock, 2,000—making a total of 13,000 tons, yielding from 15 to 40 per cent. of copper, and worth $100 per ton, or $1,300,000. In addition to this, the products of the London mine, yielding an average of 45 per cent. of copper, amounted to over $200,000 in value; and the products of the Eureka mine were rated for 1855 at $86,000; for 1856 at $123,000; and for 1857 at $136,000. The value of the ores remaining at the mines too poor to transport, but valuable to smelt in furnaces on the spot, was estimated at $200,000 more. Furnaces for smelting, on the German plan, were in operation in 1857, and produced the next year 850 tons of matt, or regulus. At the Eureka mine, in 1858, there were 4 reverberatory furnaces, 2 blast, and 2 calcining furnaces. The fuel employed is wood and charcoal. By the introduction of smelting operations, ores of 5 to 6 per cent. are now advantageously reduced.

In 1857 the mines of a large portion of this district were incorporated into the so-called Union Consolidated Mining Company, and most of the other mines were taken up by the Burra Burra Company and the Polk County Company. The principal interests in the last two are held in New Orleans. The first named own 11 mines, of which they are working three only, with a monthly production of 750 to 800 tons of 12 per cent. copper, besides 5 or 6 tons of precipitate

copper. This is metallic copper, precipitated from the waters of the mine by means of scrap iron thrown into the vats in which these waters are collected. The iron being taken up by the acids which hold the copper in solution, the latter is set free, and deposited in fine metallic powder. The ore is smelted in furnaces constructed on the German plan, and being put through twice, produce a regulus of 55 per cent. As soon as the proper furnaces and refineries can be constructed, it is intended to make ingot copper, and by working more of the mines belonging to the company it is expected the monthly production will soon be raised to 2,000 tons of 10 to 12 per cent. ore.

The two other companies have erected extensive smelting works; and the mines of the Burra Burra are producing 450 to 500 tons per month of 14 per cent. ore, and those of the Polk County Company about 300 tons of 15 per cent. ore. Both companies will soon be able to make ingot copper. The report of the Union Consolidated Company for the first year of their operations presents, against expenditures amounting to $307,182.77, receipts of $457,803.73, leaving a profit of $150,620.96. A large portion of the regulus is shipped to England for sale.

The profits of these mines were greatly reduced the first few years of their operation by the necessity of transporting the ores 40 miles to a railroad, and thence more than 1,000 miles by land and water to the northern smelting works. The establishment of furnaces at the mines not only reduces this source of loss, but renders the great body of poorer ores available, which they were not before. A railroad is now in process of construction to connect the mines with the Georgia railroads.

West of the Alleghanies, the only copper mines, besides those of Lake Superior, are in the lead region of Wisconsin, Iowa, and Missouri. A considerable number of them have been worked to limited extent, and small blast furnaces have been in operation smelting the ores. These were found only near the surface, in the crevices that contained the lead ores; and in Missouri, in horizontal beds in the limestone, along the line of contact of the granite. The ores were mixed pyritous copper and carbonate, always in very limited quantity. The amount of copper produced has been unimportant, and it is not likely that any considerable increase in the supply of the metal will be derived from this source.

The existence of native copper on the shores of Lake Superior, is noticed in the reports of the Jesuit missionaries of 1659 and 1666. Pieces of the metal 10 to 20 lbs. in weight were seen, which it is said the Indians reverenced as sacred; similar reports were brought by Father Dablou in 1670, and by Charlevoix in 1744. An attempt was made in 1771 by an Englishman, named Alexander Henry, to open a mine near the forks of the Ontonagon, on the bank of the river, where a large mass of the metal lay exposed. He had visited the region in 1763, and returned with a party prepared for more thoroughly exploring its resources. They, however, found no more copper besides the loose mass, which they were unable to remove. They then went over to the north shore of the lake, but met with no better success there. General Cass and Mr. H. R. Schoolcraft visited the region in 1819, and reported on the great mass upon the Ontonagon. Major Long, also, in 1823, bore witness to the occurrence of the metal along the shores of the lake. The country, till the ratification of the treaty with the Chippewa Indians in 1842, was scarcely ever visited except by hunters and fur-traders, and was only accessible by a tedious voyage in canoes from Mackinaw. The fur companies discouraged, and could exclude from the territory, all explorers not going there under their auspices. Dr. Douglass Houghton, the state geologist of Michigan, in the territory of which these Indian lands were included, made the first scientific examination of the country in 1841, and his reports first drew public attention to its great resources in copper. His explorations were continued both under the state and general government until they were suddenly terminated with his life by the unfortunate swamping of his boat in the lake, near Eagle river, October 13, 1845.

In 1844 adventurers from the eastern states began to pour into the country, and mining operations were commenced at various places near the shore, on Keweenaw Point. The companies took possession under permits from the general land office, in anticipation of the regular surveys, when the tracts could be properly designated for sale. Nearly one thousand tracts, of one mile square each, were selected—the greater part of them at random, and afterward explored and aban-

doned. In 1846 a geological survey of the region was authorized by Congress, which was commenced under Dr. C. T. Jackson, and completed by Messrs. Foster and Whitney in 1850. At this time many mines were in full operation, and titles to them had been acquired at the government sales.

The copper region, as indicated by Dr. Houghton, was found to be nearly limited to the range of trap hills, which are traced from the termination of Keweenaw Point toward the south-west in a belt of not more than two miles in width, gradually receding from the lake shore. The upper portion of the hills is of trap rock, lying in beds which dip toward the lake, and pass in this direction under others of sandstone, the outcrop of which is along the northern flanks of the hills. Isle Royale, near the north shore of the lake, is made up of similar formations, which dip toward the south. These rocks thus appear to form the basin in which the portion of Lake Superior lying between is held. The trap hills are traced from Keweenaw Point in two or three parallel ridges of 500 to 1,000 feet elevation, crossing Portage lake not far from the shore of Lake Superior, and the Ontonagon river about 13 miles from its mouth. They thence reach further back into the country beyond Agogebic lake, full 120 miles from the north-eastern termination. Another group of trap hills, known as the Porcupine mountains, comes out to the lake shore some 20 miles above the mouth of the Ontonagon, and this also contains veins of copper, which have been little developed until the explorations commenced near Carp lake in these mountains in 1859. These have resulted in a shipment of over 20 tons of rough copper in 1860, and give encouragement to this proving a copper-producing district. The formations upon Isle Royale, which is within the boundary of the United States, although they are similar to those of the south shore, and contain copper veins upon which explorations were vigorously prosecuted, have not proved of importance, and no mines are now worked there. The productive mines are comprised in three districts along the main range of the trap hills. The first is on Keweenaw Point, the second about Portage lake, and the third near the Ontonagon river. All the veins are remarkable for producing native copper alone, the only ores of the metal being chiefly of vitreous copper found in a range of hills on the south side of Keweenaw Point, and nowhere in quantities to justify the continuation of mining operations that were commenced upon them. The veins on Keweenaw Point cross the ridges nearly at right angles, penetrating almost vertically through the trap and the sandstones. Their productiveness is, for the most part, limited to certain amygdaloidal belts of the trap, which alternate with other unproductive beds of gray compact trap, and the mining explorations follow the former down their slope of 40°, more or less, toward the north. The thickness of the veins is very variable, and also their richness, even in the amygdaloid. The copper is found interspersed in pieces of all sizes through the quartz vein stones and among the calcareous spar, laumonite, prehnite, and other minerals associated with the quartz. These being extracted, piles are made of the poorer sorts, in which the metal is not sufficiently clear of stone for shipment, and these are roasted by firing the wood intermixed through the heaps. By this process the stone entangled among the copper is more readily broken and removed. The lumps that will go into barrels are called "barrel work," and are packed in this way for shipment. Larger ones, called "masses," some of which are huge, irregular-shaped blocks of clean copper, are cut into pieces that can be conveniently transported, as of one to three tons weight each. This is done by means of a long chisel with a bit three-fourths of an inch wide, which is held by one man and struck in turns by two others with a hammer weighing 7 or 8 lbs. A groove is thus cut across the narrowest part of the mass, turning out long chips of copper one-fourth of an inch thick, and with each succeeding cut the groove is deepened to the same extent until it reaches through the mass. The process is slow and tedious, a single cut sometimes occupying the continual labor of three men for as many weeks, or even longer. This work is done in great part before the masses can be got out of the mine. The masses are found in working the vein, often occupying the whole space between the walls of trap rock, standing upon their edges, and shut in as solidly as if all were one material. To remove one of the very large masses is a work of many months. It is first laid bare along one side by extending the level or drift of the mine through the trap rock. The excavation is carried high enough to expose its upper edge and down to its lower line; but on account of ir-

regular shape and projecting arms of copper, which often stretch forward, and up and down, connecting with other masses, it requires long and tedious mining operations to determine its dimensions. When it is supposed to be nearly freed along one side, very heavy charges of powder are introduced in the rock behind the mass, with the view of starting it from its bed. When cracks are produced by these, heavier charges are introduced in the form of sand-blasts, and these are repeated until the mass is thrown partly over on its side as well as the space excavated will admit. In speaking further of the Minesota mine, the enormous sizes of some of the masses, and the amount of powder consumed in loosening them, will be more particularly noticed.

To separate the finer particles of copper from the stones in which they are contained, these, after being roasted, are crushed under heavy stamps to the condition of fine sand, and this is then washed after the usual method of washing fine ores, until the earthy matters are removed and the metallic particles are left behind. This is shovelled into small casks for shipment, and is known as stamp copper. The stamping and crushing machinery, such as have long been used at the mining establishments of other countries, were found to be entirely too slow for the requirements of these mines, and they have been replaced by new apparatus of American contrivance, which is far more efficient than any thing of the kind ever before applied to such operations. The stamps heretofore in use have been of 100 lbs. to 300 lbs. weight, and at the California mines were first introduced of 800 lbs. to 1,000 lbs. weight. At Lake Superior they are in use on the plan of the steam hammer, weighing, with the rod or stamp-leg, 2,500 lbs. and making 90 to 100 strokes in a minute. The capacity of each stamp is to crush over one ton of hard trap rock every hour. It falls upon a large mortar that rests upon springs of vulcanized rubber, and the force of its fall is increased by the pressure of steam applied above the piston to throw it more suddenly down. The stamp-head covers about one-fourth of the face of the mortar, and with every succeeding stroke it moves to the adjoining quarter, covering the whole face in four strokes.

The only other metal found with the copper is silver, and this does not occur as an alloy, but the two are as if welded together, and neither, when assayed, gives more than a trace of the other. It is evident from this that they cannot have been in a fused state in contact. The quantity of silver is small; the largest piece ever found weighing a little more than 8 lbs. troy. This was met with at the mines near the mouth of Eagle river, where a considerable number of loose pieces, together with loose masses of copper, were obtained in exploring deep under the bed of the stream an ancient deposit of rounded boulders of sandstone and trap. The veins of even the trap rocks themselves of this locality exhibited so much silver that in the early operations of the mines a very high value was set upon them on this account. But at none of the Lake Superior mines has the silver collected paid the proprietors for the loss it has occasioned by distracting the attention of the miners, and leading them to seek for it with the purpose of appropriating it to their own use. Probably they have carried away much the greater part of this metal; at least until the stamp mills were in operation.

The principal mine of this district is the Cliff mine of the Pittsburg and Boston Company, opened in 1845, and steadily worked ever since. In 1858 the extent of the horizontal workings on the vein had amounted to 12,368 feet, besides 831 feet in cross-cuts. Five shafts had been sunk, one of which was 817 feet deep, 587 feet being below the adit level, and 230 feet being from this level to the summit of the ridge. The shaft of least depth was sunk 422 feet.

The production of the mine from the year 1853 is exhibited in the following table:—

Year.	Mineral produced. lbs.	Refined copper. lbs.	Yield per cent.	Price per lb. deducting cost of smelting.	Value realized.
1853,	2,263,182	1,071,288	47.33	cts. 27.32	$292,647 05
1854,	2,332,614	1,315,398	56.35	24.38	320,783 01
1855,	2,995,837	1,874,197	62.56	25 33	475,911 26
1856,	3,291,239	2,220,924	67.48	24.12	535,843 67
1857,	3,363,557	2,563,850	70.28	20.44	497,870 47
1858,	3,183,085	2,331,964	71.00	21.03	475,321 89
1859,	2,199,632	1,415,007	64.35	20.50	290,097 97
1860	2,805,442	..	..	..	..
	22,374,588				
Product from accumulated slags....		71,580, exclusive of slags.			

The quantities of the different sorts for the year 1857 are as follows:—

941 masses	1,958,181 lbs.
869 bbls. of barrel work	613,731 "
1,020 " of stampings	791,645 "
Total	3,363,557 "

The Portage lake mining district is from twenty to twenty-five miles west from the

Cliff mine on the same range of hills. This region is of more recent development, the explorations having been attended with little success previous to 1854. The veins are here found productive in a gray variety of trap as well as the amygdaloidal, and instead of lying across the ridges, follow the same course with them, and dip in general with the slope of the strata. Some of the larger veins consist in great part of epidote, and the copper in these is much less dense than in the quartz veins, forming tangled masses which are rarely of any considerable size. On the eastern side of this lake are worked, among other mines, the Quincy, Pewabic, and Franklin, and on the opposite side the Isle Royale, Portage, and Columbian mines. The most successful of these has been the Pewabic. Operations were commenced here in 1855 upon an unimproved tract, requiring the construction of roads and buildings, clearing of land, etc. etc., all involving for several years a continued heavy outlay. The immediate and rapid production of the mine required the construction of costly mills, without which a large proportion of the copper would be unavailable for the market. The first three years the assessments were $50,000, and the shipments of barrel and mass copper were in 1856 $97\frac{956}{2000}$ tons; in 1857, $209\frac{322}{2000}$ tons; in 1858, 402 tons; in 1859, $813\frac{778}{2000}$ tons. The proceeds from the sales up to this time paid off all the expenditures, and left besides a considerable surplus. The Franklin Company, working the same lode upon the adjoining location, commenced operations in July, 1857, and that year shipped 20 tons of copper, the next year 110 tons, and in 1859, 218 tons; the total amount in capital furnished by assessments was $10,000. These two mines have been the most rapidly developed of any of the Lake Superior mines.

The Ontonagon river crosses the trap hills about forty miles south-west from Portage lake, and the mines worked in the Ontonagon district are scattered along the hills north-east from the river for a distance of nearly twenty miles. The outlet for the greater number of them is by a road through the woods to the village at the mouth of the river. The veins of this district also lie along the course of the ridges, and dip with the trap rocks toward the lake. As they are worked, however, they are found occasionally to cut across the strata, and neighboring veins to run into each other. In some places copper occurs in masses scattered through the trap rock with no sign of a vein, not even a seam or crevice connecting one mass with another. They appear, however, to be ranged on the general course of the strata. At the Adventure mine they were so abundant, that it has been found profitable to collect them, and the cliffs of the trap rock present a curious appearance, studded over with numerous dark cavities in apparently inaccessible places leading into the solid face of the mountain.

The great mine of this district is the Minesota, two miles east from the Ontonagon river. The attention of the explorers in this region in the winter of 1847–48 was attracted by parallel lines of trenches, extending for miles along the trap hills, evidently made by man at some distant period. They were so well marked, as to be noticed even under a cover of three feet depth of snow. On examination they proved to be on the course of veins of copper, and the excavations were found to extend down into the solid rock, portions of which were sometimes left standing over the workings. When these pits were afterward explored, there were found in them large quantities of rude hammers, made of the hardest kind of greenstone, from the trap rocks of the neighborhood. These were of all sizes, ranging from four to forty pounds weight, and of the same general shape—one end being rounded off for the end of the hammer, and the other shaped like a wedge. Around the middle was a groove—the large hammers had two—evidently intended for securing the handle by

STONE HAMMER.

which they were wielded. In every instance the hammers were more or less broken, evi-

dently in service. One of them brought from the mine by the writer, and now in the collection of the Cooper Union of New York, is represented in the accompanying sketch. It measures 6¼ inches in length, the same in breadth, and 2¼ inches in thickness.

The quantity of hammers found in these old workings was so great that they were collected by cart-loads. How they could have been made with such tools as the ancient miners had, is unaccountable, for the stone itself is the hardest material they could find. And it is not any more clear, how they applied such clumsy tools to excavating solid rock nearly as hard as the hammers themselves. Every hammer is broken on the edge, as if worn out in service. The only tools found besides these were a copper gad or wedge, a copper chisel with a socket head, and a wooden bowl. The great extent of the ancient mining operations indicates that the country must have been long occupied by an industrious people, possessed of more mechanical skill than the present race of Indians. They must also have spread over the whole of the copper region, for similar evidences of their occupancy are found about all the copper mines, and even upon Isle Royale. It is not improbable that they belonged to the race of the mound builders of the western states, among the vestiges of whom, found in the mounds, various utensils of copper have been met with. But of the period when they lived, the copper mines afford no more evidence than the mounds. Some of the trenches at the Minesota mine, originally excavated to the depth of more than twenty-five feet, have since filled up with gravel and rubbish to within a few feet of the surface, a work which in this region would seem to require centuries; and upon the surface of this material large trees are now standing, and stumps of much older ones are seen, that have long been rotting. In clearing out the pits a mass of copper was discovered, buried in the gravel nearly twenty feet below the surface, which the ancients had entirely separated from the vein. They had supported it upon blocks of wood, and, probably by means of fire and their hammers, had removed from it all the adhering stone and projecting points of copper. Under it were quantities of ashes and charred wood. The weight of the mass, after all their attempts to reduce it, appears to have been too great for them to raise; and when it was finally taken out in 1848, it was found to weigh over six tons. It was about ten feet long, three feet wide, and nearly two feet thick. Beneath this spot the vein afterward proved extremely rich, affording many masses of great size.

The veins worked by the Minesota Company all lie along the southern slope of the northern trap ridge, not far below the summit. Three veins have been discovered which lie nearly parallel to each other. The lowest one is along the contact of the gray trap of the upper part of the hill and a stratum of conglomerate which underlies this. It dips with the slope of this rock toward the north-north-west at an angle of about 46° with the horizon. The next upper vein outcropping, 80 or 90 feet further up the hill, dips about 61°, and falls into the lower vein along a very irregular line. Both veins are worked, and the greatest yield of the mine has been near their line of meeting.

The position of the veins along the range of the rocks, instead of across them, gives to the mines of this character a great advantage, as their productiveness is not limited to the thickness of any one belt which proves favorable for the occurrence of the metal; and the outcrop of the vein can be traced a great distance along the surface, affording convenient opportunities for sinking directly upon it at any point.

The Minesota Company, having abundant room, have been able to sink a large number of shafts along a line of outcrop of 1,800 feet, and several of the levels below extend considerably further than this entire length. In 1858 nine shafts were in operation, and ten levels were driven on the vein, the deepest at 535 feet down the slope. The ten fathom level at that time was 1,960 feet in length. This mine is remarkable for the enormous size and great number of its masses. The largest one of these, taken out during the year 1857, after being uncovered along its side, refused to give way, though 1,450 pounds of powder had been exploded behind it in five successive sand-blasts. A charge of 625 pounds being then fired beneath it, the mass was so much loosened that by a succeeding blast of 750 pounds it was torn off from the masses with which it connected, and thrown over in one immense piece. It measured forty-five feet in length, and its greatest thickness was over eight feet. Its weight was estimated at about 500 tons. What it proved to be is not certain, as no account was preserved

of the pieces into which it was cut, but it is known to have exceeded 400 tons. Other masses have been taken out which presented a thickness of over five feet solid copper. The value of the silver picked out from among the copper has amounted in one year to about $1,000.

The reports of the company present the following statistics of the mine from its earliest operations:—

Years.	No. of men employed.	Expenditure.	Mineral product. Tons.	Per-centage	Value of Copper.	Assessments paid.	Dividends.
1848,	20	$14,000	6½	..	$1,700	$10,500	..
1849,	60	28,000	52	..	14,000	16,500	..
1850,	90	58,000	103	..	29,000	36,000	..
1851,	175	88,000	307½	..	90,000	3,000	..
1852,	212	108,000	520	..	196,000	..	$30,000
1853,	280	168,000	523	..	210,000	..	60,000
1854,	392	218,000	763	..	290,000	..	90,000
1855,	471	280,933	1,434	71	549,876	..	200,000
1856,	537	356,541	1,859	72.5	701,906	..	300,000
1857,	615	402,538	2,058	74	736,000	..	300,000
1858,	713	384,827	1,833	70.1	595,000	..	180,000
1859,	718	384,394	1,626	71	515,786	..	120,000
1860,	8 months to Sept. 1.....		1,431				
	Estimate, for the year....		2,250				

In consequence of recent discoveries of masses of copper running into the sandstone off from the vein itself, the product of the year 1860 will considerably exceed that of any other year; the profits, however, are not proportionally large, owing to the low price of copper. To this the diminished profits of 1858 and 1859 are partly to be attributed. The product for 1857, 1858, and 1859 was divided as follows:—

Years.	Masses. lbs.	Barrel work. lbs.	Stamp work. lbs.
1857,	3,015,581	819,900	280,512
1858,	2,429,989	903,871	333,352
1859,	2,040,454	929,571	282,092

Besides the dividends named, the original stockholders have derived large profits from the sale of portions of the extensive territory, three miles square, which belonged to the company, and the organization upon these tracts of new companies.

Before the completion of the St. Mary's Canal, no exact records were preserved of the amount of copper sent from Lake Superior. But up to the close of navigation in 1854 it is supposed the total shipments from the commencement of mining in 1845 had been about 7642 tons of pure copper.

Since that time, the annual product of rough copper has been as follows:—

Districts.	1855.	1856.	1857.	1858.	1859.	1860.
Keweenaw	2,245	2,128	2,200	2,125	1,910.3	1,910.8
Portage	315	462	704	1,116	1,533.1	3,064.8
Ontonagon	1,984	2,767	3,190	2,655	2,597.6	3,588.7
Porcupine, Mo., etc	..	..	..	..	..	28.1
Total	4,544	5,357	6,094	5,896	6,041.0	8,543.4

The condition of the Lake Superior mines at the close of the year 1860 is well presented in the business circular of Messrs. Dupee, Beck, & Sayles, of Boston, received since the preceding pages passed through the hands of the printer and stereotyper. From this we introduce the following additional matter. The depreciation in the price of copper from a maximum of 29½ cents a pound of the few preceding years to a maximum of 24½ cents and a minimum of 19 cents, had induced increased economy and care in the administration of the mines, the good effects of which were already beginning to be experienced:—

"Freights to and from the mines from May to September were 25 per cent. less than in 1859. The transportation of a ton of copper from the lake shore to Boston, cost, after the opening of St. Mary's Canal, 1855, $20; in 1860, to Boston, $11, and to New York, $9. The substitution of bituminous coal for wood, which has been delivered during the past summer at the wharves of Portage Lake for $3.25 per ton, will save much money and leave the forests of the country for building materials and for timbering of the mines. With the wants of a rapidly increasing population, new and cheaper sources of supply are constantly

opening in the region itself. Many agricultural products, hitherto sent up at great cost from Lower Michigan, are now raised in the neighborhood of the mines, and at the new settlements on the south-western shores of the lake, cheaply and abundantly. At Portage Lake, a machine shop, an iron foundry, and a manufactory of doors, sashes, blinds, etc., have been put in operation during 1860. The smelting works of the Portage Lake Company are now successfully refining the products of that district. These works consist of four reverberatory and two cupola furnaces, capable of refining 6000 tons per annum. The buildings are of the most thorough and substantial character, and the location of the works accessible, at a very small cost of transportation, to all the mines now wrought, or likely to be wrought for many years hence, in that neighborhood. Hitherto, to save cost of transportation to the smelting companies in other states, it has been necessary to dress the rough copper to an average probably of 70 per cent. Now, by the proximity of the furnaces to the mines, a dressing of 50 per cent. will answer the same purpose, while the refined copper, hitherto rarely ready for the market before the 1st to 15th July, will be sent directly from the lake to New York or Boston, arriving there in ordinary seasons by the 1st of June. Further, there will be added the new facility of obtaining cash advances through the winter on the warehouse receipts of the smelting company.

"The opening of the entry into Portage Lake during the past season has been one of the greatest improvements in the navigation of the Lake Superior region since the completion of the ship canal around the falls of St. Mary's river. At the comparatively small cost of $50,000, steamers of the largest class able to pass through the St. Mary's Canal may now enter Portage Lake, and discharge their cargoes at the docks of the several companies located on its shores. Besides avoiding the loss of time and expense of transhipment hitherto necessary, the opening of Portage Lake has provided one of the most capacious and safest harbors in the world.

"In the Ontonagon district, a plank road has been completed recently, facilitating to a very great extent the transportation to and from the Minesota, National, Rockland, and Superior mines.

"The iron interests of Lake Superior are rapidly attaining great importance. The amount brought down to Marquette, the port of shipment, in 1860, was: of iron ore from the Jackson Company, 62,980 tons; Cleveland Company, 47,889; Lake Superior Company, 39,394; total, 150,263. Of pig iron, Pioneer Company, 3050 tons; S. R. Gay, 1800; Northern Company, 650; total, 6500. Ore valued at $3; pig at $25; aggregate value, $588,289."

The following statistics are presented of the principal mines:—

COMPARATIVE TABLE OF SHIPMENTS OF ROUGH COPPER FROM LAKE SUPERIOR DURING THE SEASONS OF 1859 AND 1860.

The weights of the barrels have been deducted, and the results are given in tons (2000 lbs.) and tenths.

	1859.	1860.
KEWEENAW DISTRICT.		
Central	172.3	78.6
Clark	5.6	7.2
Connecticut	24.	5.3
Copper Falls	329.4	328.
Eagle River	6.	..
North American	8.7	..
Northwest	73.8	103.5
Phœnix	32.	31.2
Pittsburg and Boston	1,254.5	1,357.
Summit	4.	..
	1,910.3	1,910.8
PORTAGE DISTRICT.		
C. C. Douglass	..	24.
Isle Royale	241.3	458.6
Franklin	204.7	267.
Hancock	..	7.2
Huron	7.4	78.
Mesnard	.6	..
Pewabic	734.4	1,363.8
Portage	8.7	..
Quincy	336.	866.2
	1,533.1	3,064.8
ONTONAGON DISTRICT.		
Adventure	139.4	29.7
Aztec	15.3	4.9
Bohemian	3.	..
Evergreen Bluff	27.	41.9
Hamilton	.7	7.9
Mass	12.3	..
Minesota	1,623.6	2,183.4
National	323.2	727.8
Nebraska	9.8	26.4
Norwich	22.	..
Ogima	35.4	..
Ridge	27.8	..
Rockland	347.	552.7
Superior	1.7	14.
Toltec	9.4	..
	2,597.6	3,588.7
Keweenaw District	1,910.3	1,910.8
Portage	1,533.1	3,050.8
Ontonagon	2,597.6	3,553.7
Porcupine Mountain	..	20.5
Sundry mines	..	7.6
	6,041.0	8,543.4

Franklin: the product for the year ending November 30 has been 112 masses, weighing 72,166 lbs.; 721 barrels of barrel work, 469,116 lbs.; and, 67 barrels stamp work, 63,816 lbs. Total, 605,098 lbs., equal to $180\frac{7}{10}$ tons refined copper. The actual shipments were about 267 tons rough, or 158 tons ingot copper. The stamps are Ball's, consisting of two pairs of two heads each. They did not commence work till November 19.

Huron: total shipments this year, $65\frac{4}{10}$ tons of $64\frac{1}{2}$ per cent. barrel work, and 12,311 lbs. of refined copper, smelted at the Portage Lake works. There is ready for the stamps an amount equivalent, at a fair estimate, to the quantity shipped this season.

Isle Royale: total shipments this season $458\frac{6}{10}$ tons, averaging over 70 per cent. Preparations have been made for opening a large amount of ground during the winter, with a view to large shipments at the opening of navigation.

Minesota: November returns, 150 tons. The total shipments in 1860 were 1992 masses, and 2127 barrels of barrel and stamp work. Net weight, 4,366,718 lbs. This is the largest shipment made in one year by any mine at the lake. The promise for future production is as great, at least, as the result for this year.

Pewabic: November product, $304\frac{8}{10}$ tons. The actual shipments for the season have been 2,727,632 lbs. The product for one year to November 30 was as follows: 467 masses, weighing 348,658 lbs.; 2294 barrels kiln or barrel work, weighing net, 1,450,778 lbs.; 342 barrels No. 1, stamp, 379,718 lbs.; 399 barrels No. 2, stamp, 389,973 lbs.; 401 barrels No. 3, stamp, 346,912 lbs.; add on tributers' account, 27,428. Total, 2,943,467 lbs.

The smelting returns are not yet all made, but on an estimate based on past experience, the result will not vary much from 2,030,992 lbs., or about 1000 tons of ingot copper.

During the year there have been shipped 1533 ounces of silver.

Pittsburg and Boston: November product, 114 tons. Total shipments, 1357 tons. Total product for the year, 1402 tons. The annual report recently published gives the result of the year ending December 1, 1859. The product for that year was $1,099\frac{3}{10}$ tons, yielding $64\frac{35}{100}$ per cent., or $707\frac{5}{10}$ tons ingot copper. The receipts, including $2,405 17 from sales of silver, were $292,503 14. The expenditures were $272,175 75, leaving net profit, $20,327 39.

COPPER SMELTING

The ores of copper, unlike those of most of the other metals, are not in general reduced at the mines; but after being concentrated by mechanical processes called dressing—which consist in assorting the piles according to their qualities, and crushing, jigging, and otherwise washing the poorer sorts—they are sold to the smelters, whose establishments may be at great distances off, even on the other side of the globe. The richer ores, worth per ton three or four times as many dollars as the figures that represent their percentage of metal, well repay the cost of transportation, and are conveniently reduced at smelting works situated on the coast near the markets for copper, and where the fuel required for their reduction is cheap. At Swansea, in South Wales, there are eight great smelting establishments, to which all the ores from Cornwall and Devon are carried, and which receive other ores from almost all parts of the world. It is stated that in this district there are nearly 600 furnaces employed, which consume about 500,000 tons of coal per annum, and give employment to about 4,000 persons besides colliers. The amount of copper they supply is more than half of that consumed by all nations. The total product of fine copper produced by all the smelting establishments of Great Britain for 1857 is stated to be 18,238 tons, worth £2,079,323.

The copper-smelting works of the United States are those upon the coast, depending chiefly upon foreign supplies of ores, and those of the interior for melting and refining the Lake Superior copper. There are also the furnaces at the Tennessee mines, which have been already noticed. The former are situated at the following localities: At Point Shirley, in Boston harbor, are the furnaces of the Revere Copper Company, which also has rolling mills and other works connected with the manufacture of copper at Canton, on the Boston and Providence railroad. At Taunton, Mass., a similar establishment to that at Canton is owned by the Messrs. Crocker, of that town. There are smelting furnaces at New Haven, Conn.; at Bergen Point, in New York harbor; and at Baltimore, on a point in the outer harbor.

The furnaces established for working the Lake Superior copper are at Detroit, Cleveland, and Pittsburg. At the last named are two separate establishments, with each of which is connected a rolling mill, at which the ingot copper is converted into sheets for home consumption and the eastern market. A furnace was also built at Portage lake, Lake Superior, in 1860, of capacity equal to melting 6000 tons of copper annually. The details and extent of the operations carried on by the smelting works appear to have been carefully kept from publication. In a work on "Copper and Copper Smelting," by A. Snowdon Piggott, M. D., who had charge of the chemical assays, etc., for the Baltimore Company, published in 1858, while the English processes are fully described, no information is given as to the methods adopted at the American works; and of their production all the information is contained in the two closing sentences of the appendix, as follows: "Of the copper-smelting establishments of the United States I have no statistics. Baltimore turns out about 8,000,000 pounds of refined copper annually." Applications which have been made by the writer to the proprietors of several of the establishments for information as to the business, have been entirely unsuccessful. The total production of copper in 1858 was supposed to be about 13,000 tons per annum; and of this about 7000 tons were required by the rolling mills for making sheet copper, sheet brass, and yellow metal.

The French treatise on Metallurgy by Professor Rivot contains the only published description of the American method of smelting copper. By the English process, the separation of the metal from its ores is a long and tedious series of alternate roastings or calcinations, and fusions in reverberatory furnaces. The system is particularly applicable to the treatment of poor, sulphurous ores contaminated with other metals, as iron, arsenic, etc., and can only be conducted to advantage where fuel is very cheap, the consumption of this being at the rate of about 20 tons to the ton of copper obtained. The process employed in Germany is much more simple, and the methods in use at the American smelting works are more upon the plan of these. Blast or cupola furnaces supply at some of them the place of reverberatories, and the separation of the metal is completed in great part by one or two smeltings. The treatment of the Lake Superior copper is comparatively an easy operation. For this large reverberatory furnaces are employed, through the roof of which is an opening large enough to admit masses of 3 to 3½ tons weight, which are raised by cranes and lowered into the furnace. The barrels of barrel work are introduced in the same way, and left in the furnace without unpacking. When the furnace is charged, the opening in the top is securely closed by fire-proof masonry, and the fire of bituminous coal is started, the flame from which plays over the bridge, and, reflected from the roof, strikes upon the copper, causing it gradually to sink down and at last flow in a liquid mass. A small portion of the copper by the oxidizing action of the heated gases is converted into a suboxide, which is partially reduced again, and in part goes into the slags in the condition of a silicate of copper, the metal of which is not entirely recovered. The mixture of quartz, calcareous spar, and epidote accompanying the copper, is sometimes such as to melt and form a good cinder without addition of any other substance, but usually some limestone or other suitable material is added as a flux. Complete fusion is effected in 12 to 15 hours according to the size of the masses, and this is kept up for about an hour in order that the fine particles of copper may find their way through the fluid slag, which floats upon the metal. Working tools called rabbles are then introduced through the side-doors of the furnace, and the charge is stirred up and the slag is drawn out through the door. It falls upon the ground, and is taken when sufficiently cool to the cupola or slag furnaces where it is chilled with water to render it easy to break up. Those portions which contain as much as one fourth per cent. of copper are reserved to be passed through the slag furnace. The total amount of slag is usually less than 20 per cent. of the whole charge. In the melting the copper absorbs carbon, which if allowed to remain would render it brittle and unfit for use. To remove it the fire is so arranged that the gases pass through with much unconsumed air; this playing on the surface of the copper produces a suboxide of the metal, which in the course of half an hour is quite taken up by the copper, and coming in contact with the particles of carbon the oxygen combines with this, and removes it in the form of carbonic acid gas.

It now remains to remove the excess of oxygen introduced, which is effected by the ordinary method of refining. A large proportion of fuel is employed on the grate for the amount of air admitted through it, so that the flames as they pass over the bridge convey little free oxygen, and the surface of the metal is covered with fine charcoal. After a little time a pole of green wood is thrust into the melted copper and stirred about so long as gases escape from the surface. It is then taken out, and if on testing the copper some suboxide still remains, the refining is cautiously continued with charcoal, and just when, as appears by the tests, all the oxide is reduced, the work of dipping out the metal is commenced. This is done by large iron ladles, the whole set of men employed at two furnaces, to the number of about 12, coming to this work and taking turns in the severe task. They protect themselves from the intense heat by wet cloths about their arms, and as quickly as possible bale out a ladle full of copper and empty it into one or more of the ingot moulds, of which 36 are arranged in front of the furnace-door upon three parallel bars over a trough of water. As the metal becomes solid in each mould, this is upset, letting the ingot fall into the water. The weight of the ingot being 20 pounds, the filling of them all removes 720 pounds of copper from the furnace. The metal that remains is then tested, and according to its condition the discharging may be continued or it may be necessary to oxidize the copper again and repeat the refining, or merely to throw more charcoal upon the surface and increase the heat. The time required to ladle out the whole charge is from four to six hours. When this is completed the sole of the furnace is repaired, by stopping the cracks with sand and smoothing the surface to get all ready for the next charge; and at the same time the second furnace has reached the refining stage of the process. One charge to a furnace is made every evening, and as in the night it is necessary only to keep up the fires, the great labor of the process comes wholly in the day time.

The following is the estimated cost at Detroit of the smelting, on a basis of two furnaces, each of which is charged with four and a half to five tons of mass copper, consuming two and a half tons of coal, and producing from three to three and a half tons of ingots:—

Labor, 15 hands, at $1.50	$22.50
Bituminous coal, 5 tons, at $5	25.00
Wood and charcoal	1.25
Repairs to furnace, average for the season	2.00
	$50.75

To this should be added, for superintendence, office, and general expenses, perhaps ten dollars more, which would make the cost for six or seven tons of ingot copper, $60.75, or $9 to $10 per ton. At Pittsburg the rate charged has been $11 per ton; and fuel is there afforded at about one third the amount allowed in the above estimate.

The cupola furnaces for treating the slags are of very simple plan and construction. They are of cylindrical form, about ten feet high, and three feet diameter inside. Their walls, the thickness of a single length of fire brick, are incased in boiler-plate iron, and stand upon a cast-iron ring, which is itself supported upon four cast-iron columns about three feet above the ground. Transverse iron bars support a circular plate, and upon this the refractory sand for the sole of the furnace is placed, and well beaten down to the thickness of a foot, with a sharp slope toward the tapping hole. A low chimney conveys away the gaseous products of combustion, and through the base of it the workmen introduce the charges. The blast is introduced by three tuyeres a foot above the sole; but before it enters the furnace it is heated by passing through a channel around the furnace. A steady current is obtained by the use of three double acting blowing cylinders, which give a pressure equal to about three and a half inches of mercury.

The hands employed at the Detroit establishment, besides the superintendent and head smelter, are eighteen furnace men and from five to ten workmen, according to the arrivals of copper during the season of navigation. After the stock thus received is worked up, the furnaces remain idle during the remainder of the winter.

USEFUL APPLICATIONS OF COPPER.

The uses of copper are so numerous and important that the metal must rank next in value to iron. In ancient times, indeed, it was the more useful metal of the two, being abundant among many nations to whom iron was not known. In the ancient Scandinavian tumuli recently opened in Denmark, among the various implements of stone were found swords, daggers, and knives, the blades of which were, in some instances, of copper,

and in some of gold, while the cutting edges were formed of iron, showing that this was more rare and valuable than either copper or gold. It has been supposed that several of the ancient nations, as the Egyptians, Greeks, etc., possessed the art of hardening copper, so as to make it serve the purposes of steel. That they employed it for such uses as those to which we now apply tools of steel is certain, and also that the specimens of some of their copper tools are considerably harder than any we make of the same metal. These are found, on analysis, to contain about one part in ten of tin, which, it is known, increases, when added in small proportions, the hardness of copper, and this was probably still further added to by hammering.

Among the most important uses of the metal at present is that of sheathing the bottoms of ships in order to protect the timbers from the ravages of marine animals, and present a smooth surface for the easy passage of the vessel through the water. The metal is well adapted, from its softness and tenacity, for rolling into sheets, and these were first prepared for this use for the Alarm frigate of the royal navy, in 1761. Sheet lead had been in use before this time, but was soon after given up for copper. On account of the rapid deterioration of the copper by the action of the sea-water, the naval department of the British government applied, in 1823, to the Royal Society for some method of preserving the metal. This was furnished by Sir Humphry Davy, who recommended applying strips of cast iron under the copper sheets, which, by the galvanic current excited, would be corroded instead of the copper. The application answered the purpose intended, but soon had to be given up, for the copper, protected from chemical action, it was found, became covered with barnacles and other shell-fish, so as seriously to impair the sailing qualities of the vessels, and for this reason it has been found necessary to submit to the natural wasting of the metal, and replace the sheets as fast as they become corroded.

Various alloys have been proposed as substitutes for copper. That known as yellow metal, or Muntz's, has been the most successful and has been very generally introduced. It consists of copper alloyed with about 40 per cent. of zinc, and is prepared by plunging cakes of zinc into a bath of melted copper contained in a reverberatory furnace. The volatilization of the zinc and oxidation of the metals is guarded against by a covering of fine charcoal kept upon the melted surface. The bolts, nails, and other fastenings for the sheathing, and for various other parts of the ship, are made also of copper and of yellow metal; and to secure the greatest strength, they should be cast at once in the forms in which they are to be used. The manufacture of all these articles is extensively carried on at the different copper establishments in Massachusetts, Connecticut, and Baltimore.

Sheet copper is also applied to many other very important uses, as for copper boilers and pipes, for large stills and condensers, the vacuum pans of sugar refineries, and a multitude of utensils for domestic purposes, and for employment in the different arts. For engraving upon it is prepared of the purest quality and of different thicknesses, according to the kind of engraving for which it is to be used. The engraver cuts it to the size he requires, planishes it, and gives to it the dead smooth surface peculiar to engraving plates. The smaller utensils of sheet copper, as urns, vases, etc., are very ingeniously hammered out from a flat circular sheet. As the hammering is first applied to the central portion, this spreads and takes the form of a bowl. As the metal becomes harder and brittle by the operation, its softness and ductility are restored by annealing, a process that must often be repeated as the hammering is continued, and toward the last, when the metal has become more susceptible to the change induced by the application of the hammer, the annealing must be very carefully attended to, and the whole process be conducted with much skill and judgment acquired by long experience.

For larger and more common hollow articles, the sheet copper is folded around, and lapped by various sorts of joints, some of which are secured by rivets, and some by a double lap, the two edges locking into each other, and made close by hammering. The edges are also soldered either with soft or hard solder. For the latter an alloy is made for the purpose, by melting in a crucible a quantity of brass, and then stirring in one-half or one-third as much zinc, until the blue flame disappears. The mixture is then turned out into a shallow pan, and when cold the plate is heated nearly red hot, and beaten on an anvil or in a mortar. This is the hard solder of the braziers.

A still more important application of the

copper is in the manufacture of the alloy known as brass; and that called bronze also serves many useful purposes. The former is composed of copper and zinc, the latter of copper and tin. It is a curious fact in metallurgy that brass was extensively manufactured, and used more commonly than any single metal or other alloy, many centuries before the existence of such a metal as zinc was known. It was prepared by melting copper and introducing fragments of the *lapis calaminaris*, an ore of zinc, in which the oxide of the metal is combined with carbonic acid. Charcoal was also added to the mixture, and by the reaction with this the zinc ore was reduced to the metallic state, and at once united with the copper, without appearing as a distinct metal. This process is still in use for making brass, but the more common method is to introduce slips of copper into melted zinc, or to plunge beneath melted copper lumps of zinc held in iron tongs. The proportion of the two metals is always uncertain, owing to the unknown quantity of zinc that is consumed and escapes in fumes This is prevented as much as possible by covering the melted metal with fine charcoal, and by throwing in pieces of glass, which melt and cover the mixture with a thin protecting layer. Old brass is much used in making new, and the addition of quantities of this to the pot containing the other ingredients, adds to the uncertainty of the composition. The best proportion of the two metals is believed to be two parts of copper to one of zinc, which is expressed by the term "eight-ounce brass," meaning eight ounces of zinc to sixteen of copper. Sixteen-ounce brass—the two metals being equal—is a beautiful golden yellow alloy, called prince's metal. But all brass of more than ten ounces of zinc to the pound of copper is whitish, crystalline, hard, and brittle; of less than ten ounces it is malleable, soft, and ductile. The alloys known as pinchbeck, Manheim gold, bath metal, etc., formerly much in use as imitations of gold, are about three to four ounce brass.

Brass combines a great number of excellent qualities, which render it adapted for a multitude of uses. Its compactness, durability, strength, and softness, render it an excellent material for fine work, and nothing, except tin, perhaps, is a more agreeable substance for shaping in the lathe. In use it is not liable to rust by exposure, is easily kept clean, and takes a polish almost as beautiful as that of gold. It is hence a favorite material for the works of watches and clocks, almost all sorts of instruments in which great hardness is not essential, and for various household utensils, and ornaments upon furniture. In thin plates it is stamped and embossed in figures, and is thus cheaply applied to many useful and ornamental purposes. Its ductility is such, that those sorts containing little zinc can be beaten out, as will be described in the account of gold-beating, almost like gold-leaf itself, so as to be used as a cheap substitute for this in gilding in some cases. It is also drawn out into wire, often of great fineness; and of the suitable sizes of this there is a very large consumption in the manufacture of pins, and hooks and eyes. The consumption of copper alone for these articles at the factories at Waterbury, Connecticut, has amounted for some years past to more than a ton a day. By ingenious machinery the brass wires are clipped to their proper length for pins, pointed, headed, and after being tinned, are stuck in paper, with very little attention from the workmen. This manufacture used often to be cited as an example of the economical division of labor, showing the great number of workmen through whose hands a single pin passed before it was completed. It serves better now to exemplify the perfection of machinery, and some of the most admirable of this, particularly that by which the finished pins are stuck in their papers, is a peculiarly American invention, and worth, to the manufacturers at Waterbury alone, many thousand dollars annually. The solid-headed pin, made somewhat after the manner in which cut nails are headed, was invented by two citizens of Rhode Island, Mr. Slocum and Mr. S. G. Reynolds. This was before the year 1840. The covering of the brass pins and hooks and eyes with the slight coating of tin is effected by placing a quantity of them in a scouring barrel, together with about twice their weight of tin in grains, several ounces of cream of tartar, and several gallons of warm water. The barrel is then made to revolve upon its axis, until the pins or other articles are perfectly clean. After this they are boiled in a similar mixture.

Much of the brass of the ancients was properly bronze—that is, a compound of copper and tin. This alloy, in different proportions of its ingredients, is still of very great service. Gun metal—the material of the so-called brass cannon—is composed of copper

96 to 108 parts, and tin 11 parts. The compound resists wear extremely well, but its strength is only about one-half that of wrought iron. Statues, and hard castings for machinery, are formed of this alloy, and the former have very commonly been cast from cannon captured in the victories of the commander in whose honor the statues were made. One of the most noted foundries for the casting of cannon, statues, and bronze ornaments in the United States is that of the Messrs. Ames, at Chicopee, Mass. The equestrian statue of Washington, in Union square, New York, is one of their most successful productions. The French bronze contains 2 parts of tin, 1 of lead, 6 of zinc, and 91 of copper. Bell-metal is a bronze usually consisting of 7 parts of copper and 22 of tin. Their manufacture has been carried on at different copper foundries in the United States for many years. The largest bell in the country, that upon the City Hall, in New York, weighs 23,000 pounds, and was cast in Boston. The largest number of bells is probably produced at the foundry of the Messrs. Meneely, at Troy, N. Y. The Chinese gong is now an American manufacture, composed of bell-metal, which, after being cast, is forged under the hammer, between two disks of iron. The casting is made malleable by plunging, while hot, into cold water.

As with zinc copper forms an alloy made to imitate gold, so with tin and nickel it is made to form a combination resembling silver, and known as German silver. The proportions of the metals are 8 parts of copper to either 3 or 4 each of the two other metals. This is a very useful alloy, answering as a cheap substitute for silver in spoons, forks, and other utensils, and for brass in various instruments. It takes the place of the old-fashioned pewter, and, being cheaply electro-plated with silver, is made as beautiful as the genuine articles of the richer metal.

Another alloy of the copper and tin is the telescope or speculum metal, which consists of about one-third tin and two-thirds copper. It is of a steel-white color, very hard and brittle, and susceptible of a high polish, which is not soon tarnished, qualities that cause it to be used for the mirrors of telescopes.

In coinage copper is largely employed —in the old cent unalloyed, and in the new combined with 12 parts in 100 of nickel.

CHAPTER III.

GOLD.

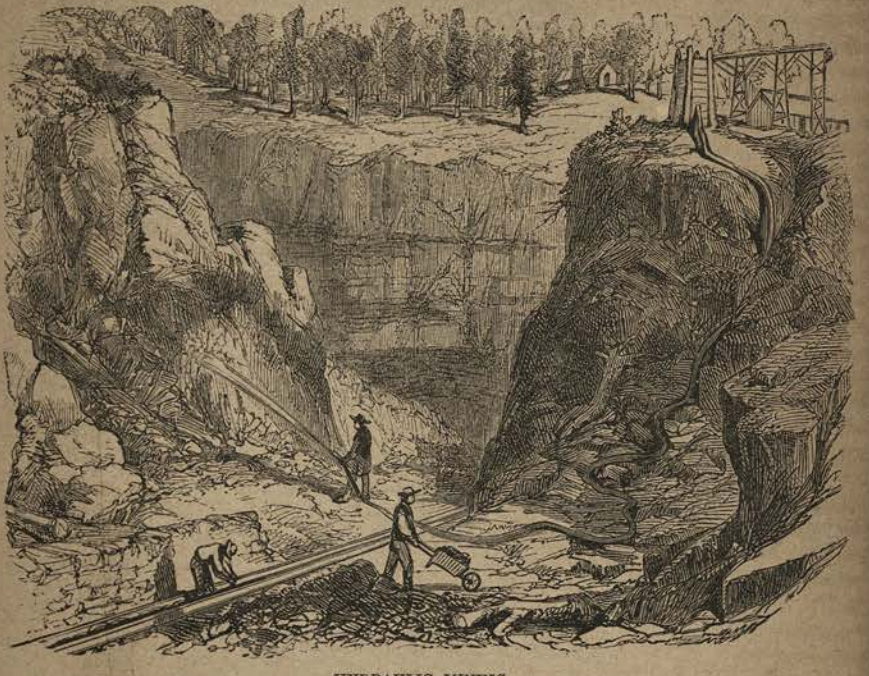
ALTHOUGH the discovery of gold mines was the chief motive that led to the settlement of the American continent, those of the United States appear to have escaped notice until the present century. The only exception to this may be in the discovery made by some Europeans of the gold region of northern Georgia at a period long antecedent to the occupation of this district by the whites. Of this fact no written record is preserved; but in working the deposit mines of the Nacoochee valley, in Habersham county, there were discovered, about the year 1842, various utensils and vestiges of huts, which evidently had been constructed by civilized men, and had been buried there several centuries. It is supposed they belonged to De Soto's party, which passed through this region in the sixteenth century on their exploring expedition from Florida to the Mississippi river. The earlier historians hardly mention gold as even being supposed to exist in the colonies. Salmon, in the third volume of his "Modern History," 1746, merely alludes to a gold mine in Virginia, which of late "had made much noise," but does not even name the locality, and evidently attaches no importance to it. In Jefferson's "Notes on Virginia" mention is made of the discovery of a piece of gold of 17 dwts. near the Rappahannock. In 1799, as mentioned by Wheeler in his "History of North Carolina," a son of Conrad Reed picked up a piece of gold as large as a small smoothing iron from the bed of a brook on his father's farm, in Cabarrus county, and its value not being known it was kept for several years in the house to hold the door open, and was then sold to a silversmith for $3.50. In Drayton's "View of South Carolina," 1802, the metal is stated to have been found on Paris Mountain, in Greenville district. About this time it began to be met with in considerable lumps in Cabarrus county, N. C., and not long afterward in Montgomery and Anson counties. At Reed's mine, in Cabarrus, the discovery by a negro of a lump weighing 28 lbs. avoirdupois, near the same stream already referred to, led to increased activity in exploring the gravelly deposits along the courses of the brooks and rivers of this region, and numerous new localities of the metal were rapidly discovered. A much larger proportion of

gold was collected, during these earlier workings, in coarse lumps than in the operations of later times—pieces of metal of one to several pounds weight being often found. Before the year 1820, as stated in *Bruce's Mineralogical Journal* (vol. i., p. 125), the quantity of American gold received at the mint at Philadelphia amounted to $43,689. All of this was from North Carolina. In 1827 there had been received from the same source $110,000. But besides this amount, a considerable proportion of the gold product was consumed by jewellers, who paid a better price than was received from the mint, and was retained by the banks, in which it was deposited. It also circulated to some extent as a medium of exchange in the mining region, being carried about in quills, and received by the merchants usually at the rate of ninety cents a dwt. The total product of the mines must, therefore, have been much larger than appears from the mint returns. In 1829, Virginia and South Carolina began to appear as gold-producing states —there being deposited in the mint from the former gold to the value of $2,500, and from the latter of $3,500. The same year the rich gold deposits of northern Georgia were discovered, and suddenly became very productive, so that the receipts at the mint from this state for the year 1830 amounted to $212,000. Gold mining had now become an established branch of the productive industry of the states, and as its importance increased, the necessity was felt of the establishment of branch mints in the mining region. One was constructed by act of Congress at Dahlonega, Lumpkin county, Georgia, and another at Charlotte, Mecklenburg county, N. C.; and both commenced coining gold in 1838. From the irregular manner in which the gold deposits were worked, and their uncertain yield, the annual production of the mines was very variable. In a single year the mint at Dahlonega received and coined gold to the value of $600,000; and until the discovery of the California gold mines, the American production was estimated to average annually about $100,000. It was, however, gradually declining in importance from the year 1845; and of late years has dwindled away, so as not to amount to enough for the support of the branch mints, the abolition of which by act of Congress was generally looked for in 1857 and 1858. The late introduction at the mines of North Carolina and Georgia of the hydraulic and sluice washing, which has proved highly successful in California, gives encouragement that these mines may again soon became as productive as before.

The rock formations of the United States, in which gold mines are worked, follow the range of the Appalachians, and are productive chiefly along their eastern side in a belt of country sometimes attaining a width of 75 miles, as along the southern part of North Carolina, and in Georgia in two distinct belts which are separated by a district of formations unproductive in gold. The extreme northern gold mines on this range are in Canada East, upon the Chaudiere river and its tributaries, the Du Loup and the Touffe des Pins. In 1851 and 1852, deposits were worked upon these streams, and about 1,900 dwts. were collected — found among the gravel which lay in the crevices formed by the ragged edges of the upturned argillaceous and talcose slates. The pieces were all small, only one weighing as much as 4 ounces. The returns were not sufficient to cover the outlays, and the working was consequently abandoned.

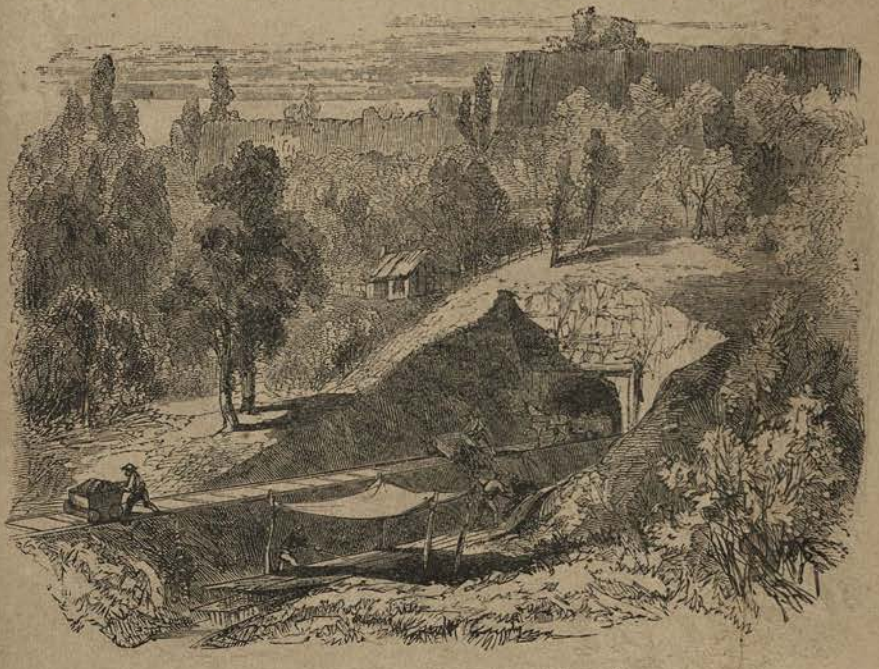
The next localities on the range toward the south which have furnished gold are in Vermont, on the western border of Windsor county, in the towns of Bridgewater and Plymouth. At Newfane, in Windham county, a piece of gold was found in 1826, which weighed 8½ oz.; but the only successful attempts to work the deposits were commenced in 1859, in Windsor county, and have since been prosecuted to limited extent. At Bridgewater, the gold has been found in place, in a quartz vein, associated with galena, and pyritous copper, and iron. It has not proved sufficiently rich to work. Through western Massachusetts and Connecticut, and the south-east part of New York, and through New Jersey and Pennsylvania, the talcose and argillaceous slates, and the other rocks of the gold belt, appear to be unproductive in this metal, a little gold only having been met with in some of the ores worked for lead and copper in Lancaster county, near the borders of Maryland. Specimens of quartz rich in gold have been found in Montgomery county, in the last-named state; but no mine has been worked there.

In Virginia the deposit mines of Louisa county especially were very productive even in 1833, and they had not been worked long before rich veins were found, and operations



HYDRAULIC MINING.

By this operation, as described in the text, hills of loose materials or of decomposed slates and other rocks containing gold, are washed down, and the earthy matters are swept away through the sluices made either of wooden troughs or by excavating channels in the bed-rock. In these the coarse gold is caught against the bars placed at intervals across the sluices. This is a purely Californian method, and has proved so effectual in collecting the little gold buried in large bodies of earth, that it is now generally adopted in other gold regions in which the conditions are favorable for its practice.



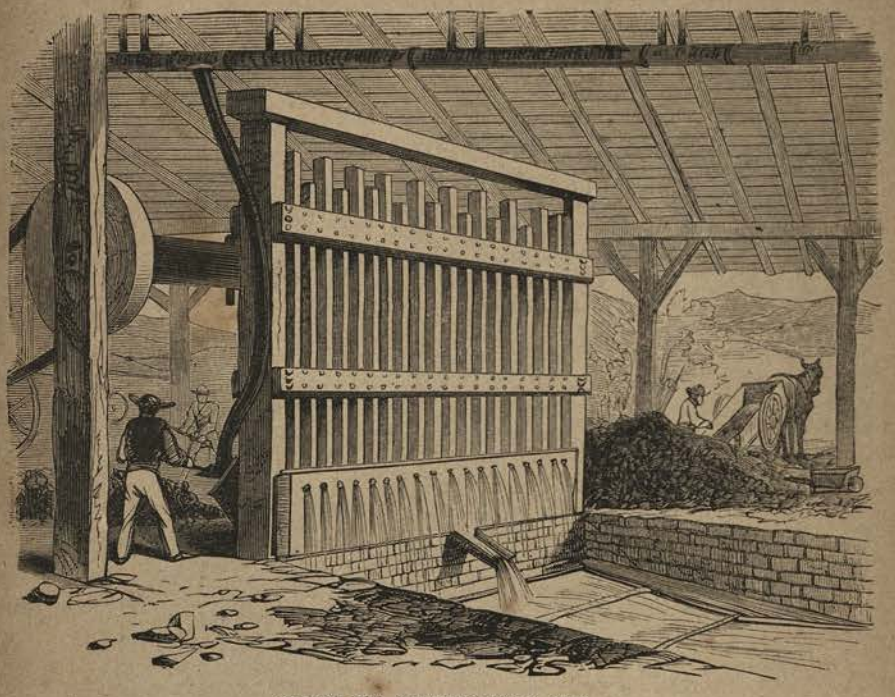
TUNNELLING AT TABLE MOUNTAIN, CALIFORNIA.

This represents a common method of reaching beds of rich ores that lie at considerable depths below the surface, by which the labor of removing the superficial deposits is avoided. Veins of ores, whether lying at a steep or gentle inclination, are often explored by such tunnels driven in upon their course. The sides and roof may be protected or not, as the ground is soft or solid, by timbering.

At the outside of the tunnel below the railroad track is the machine called the "long tom," a shallow trough, ten to twenty feet long, and about sixteen inches wide. The lower end, which turns up gently from the plane of the bottom, is shod with iron and perforated with holes. The water from the mine is turned on the upper end, and flows up this slope and through the holes, carrying with it the finer mud and sand which are continually thrown into the tom. One man at the lower end keeps the mud in motion and removes the coarse lumps. Under the lower end of the tom is placed a "riffle box," in which mercury may be used to advantage if the gold is in fine particles.

LARGE ROCKER USED IN CALIFORNIA WITH QUICKSILVER.

The above cut represents a rocker of unusual dimensions, which has been introduced in some places in California, and is employed particularly for auriferous deposits in which the gold is in too fine particles to be caught in the long tom. It is slightly inclined, and is rocked by one man while the others collect the gravel and throw it upon the perforated iron plate. Across the bottom of the trough are placed "riffle bars," and behind each one of these some mercury. The fine particles of gold coming in contact with this are caught and retained in the form of amalgam. The coarse gravel falls off the lower end of the plate, while the fine mud and sand are washed by the water through the holes in the plate.



STAMPS FOR CRUSHING GOLD ORES.

This cut represents a common form of stamps, such as are used for pulverizing auriferous quartz or other ores. They are variously arranged at different mills; sometimes four or five running in one set, and several sets being placed on the same line, but separate from each other. This arrangement is more convenient for stopping a portion at a time as may be required for repairs or for collecting the very coarse gold under the stamps which cannot pass through the grating or the plates, perforated with many holes, that are usually employed in front of the stamps.

upon these had been carried on to considerable extent previous to 1836, principally in the counties of Spottsylvania, Orange, Louisa, Fluvanna, and Buckingham. Some of the mines produced at times very rich returns, but their yield was, for the most part, exceedingly irregular, the gold occurring in rich pockets or nests, very unequally scattered in the vein. The occasional richness of the veins caused the attention of wealthy capitalists in this country and in England to be directed to this region, and large outlays were made, in providing powerful engines and other suitable machinery for working the ores, and in opening the mines. But, although the operations have been directed by the best mining skill, supported by abundant capital, the enterprise, on the whole, has not proved successful, and since 1853 the business has greatly declined in importance.

In North Carolina numerous quartz veins have been worked during the last 30 years, and operations are still carried on with moderate success at several mines in Guilford, Davidson, Montgomery, Cabarrus, Rowan, and Mecklenburg counties. Deposit mines have been worked with great success, also, in Burke, Rutherford, and McDowell counties. At a single time, it is stated, there might have been seen, from one point of view in McDowell county, no less than 3,000 persons engaged in washing the deposits. In this district sluice-washing has recently been successfully introduced by Dr. Van Dyke, who is also engaged in the same process in Georgia. The most important group of mines is at Gold Hill, on the southern line of Rowan and Cabarrus counties. Mining operations were begun here in 1843, and for 10 years the annual product averaged about $100,000; the last four years of this period more than one-third of all the gold coined at the Charlotte mint was from Gold Hill. In 1853 the property was purchased by a New York company, by which it has since been worked, but with greatly reduced profits, although the mines have been furnished with the most efficient machinery. These are the deepest gold mines in the Atlantic states, one of the shafts having now reached the depth of 680 feet. The ore is pyritous iron, containing gold in particles rarely visible, and probably chemically combined with the iron and sulphur in the form of a double sulphuret. It is separated with difficulty, and very imperfectly, by the processes of crushing and amalgamating; and the immense heaps of tailings collected below the mines, amounting probably to over two million bushels, still retain quantities of gold worth from fifty cents to two dollars the bushel. In Davidson county a mine was opened in 1839, which produced in the three succeeding years about $7,000 worth of gold, when the ore was proved to be more valuable for silver than for gold. These metals were associated with a variety of metallic ores, among which the sulphuret, carbonate, and phosphate of lead were especially abundant. Furnaces were constructed for reducing these, and separating the silver obtained with the lead. This is the only mine east of the Rocky Mountains which has furnished any considerable amount of silver to the mint. It is now known as the Washington mine.

Although many gold mines have been worked in South Carolina, the only one of much note is the Dorn mine, in Abbeville district. In 1850 this mine, then quite new, produced gold to the value of $19,000, and in 1852 the production rose to $202,216, although the mine was provided with very imperfect machinery and worked in a very rude manner. This large yield was, however, of short duration, the gold occurring in great quantity only in streaks or pockets upon a short portion of the vein.

The Georgia gold mines, first worked in the north-east part of the state in 1829, were soon found to extend south-west into the country beyond the Chestatee river, which was then possessed by the Cherokee Indians. In 1830 the borders of this territory were overrun by a reckless set of adventurers, notwithstanding the attempts made, first by a force of United States troops stationed for the protection of the Indians, and afterward by Georgia troops, when the state extended her laws in 1830 over the Cherokee country. On the removal of the Indians, their lands were distributed in 40 acre lots, by lottery, among the inhabitants of the state, and thus titles were obtained to the gold mines. The deposit mines yielded richly for a few years, and the whole product of gold for the first ten years of their working is supposed to have amounted to $16,000,000, a large portion of which never reached the United States mints, but was distributed in barter throughout the neighboring states and worked up in jewelry. From 1839 to 1849 the production did not probably exceed $4,000,000. A number of quartz veins were opened in Habersham, Lumpkin, Cherokee, Carroll, Colum-

bia, and other counties, and considerable amounts of gold were obtained from these. They were, however, generally abandoned when the workings reached a depth at which machinery would be required for draining the mines. In Columbia county, about 20 miles from Augusta, the McCormack mine has been worked without interruption for about 20 years steadily, producing very fair profits. The gold is found in small particles in a honey-combed quartz, which contains but little pyrites and some galena. Nearly all the gold was obtained within 70 feet of the surface.

In Lumpkin county the gold is found in immense beds of decomposed micaceous and talcose slates, which, too poor to be worked by the slow process of crushing the whole material in mills and then washing away the earthy matter, will probably well repay the more thorough system of operations according to the California hydraulic process. After these beds had remained neglected for many years, Dr. H. M. Van Dyke, who had gained experience in California, and already applied it in introducing the system into North California, found in Boston, Mass., capitalists who agreed to furnish the money required for securing the richest tracts in the vicinity of Dahlonega, and conveying to them the water for washing down the hills on the plan, which will be more particularly noticed in speaking of the California mines. In 1858 he commenced operations, which have since been actively conducted; taking the water of the Yahoola river at a point about 13 miles above the spot where it will be first used, and conveying it by a canal or ditch over the more elevated portion of the country, crossing the valleys by means of sluices supported upon trestle-work, the height of which gradually increases with the descent of the streams, until at the crossing of the Yahoola near Dahlonega the high trestle now in construction is at the level of 240 feet above the bed of the river, with a span between the hills of 1,400 feet. Beyond this crossing the canal is to be extended two miles further, to reach the rich deposits upon which the hose washing will be first applied. It is expected that the arrangements will be completed early in 1861, and that from the numerous localities controlled by the company, at which the water can be used to advantage, the proceeds will revive the reputation of the Georgia gold mines.

Another association was formed in Boston in 1857, called the Nacoochee Hydraulic Mining Company, for the purpose of applying the same system to the high grounds in White county, recently a part of Habersham, in which are the mines of the Nacoochee valley and its vicinity, at one period highly productive, and where many deposits exist at so great an elevation, that no water has heretofore been brought to bear upon them. By damming the Nacoochee river, this company can carry water to these points; and their arrangements are already nearly completed. In some experimental trials they have, by the use of a current of water that would flow through a six-inch pipe, obtained several hundred dollars per week with the labor of two miners. From one spot more than 1,500 dwts. were washed out in small nuggets, several of about 100 dwts. each, and one of 387 dwts. The value of these is $1 the dwt., and of the gold dust 97 cents. The auriferous belt of rocks consists of alternating beds of micaceous, hornblende, and talcose slates and gneiss, which stand nearly vertically, and contain between their layers bands of quartz. The gold is found in the quartz and in the auriferous pyrites accompanying it, and to some extent in the slates also. Detached or "free" gold is also met with, derived, no doubt, from pyrites which has decomposed and disappeared. From the general disintegration of the edges of these strata, gold has been distributed in the deposits around.

From Georgia, the gold-bearing rocks are traced into eastern Tennessee, where they have been worked along the range of the Coweta and Smoky Mountains; and from the south side of the Blue Ridge, in Georgia, they have proved productive in a south-west direction, through Carroll county, into Alabama; but the formation is soon lost in the last-named state.

Another gold region is found along the Rocky Mountain range, on its eastern side; but though the existence of gold has long been known at Santa Fé, and mines in its vicinity have produced from $30,000 to $250,000 per annum, little attention has been directed to this district until the discovery of deposits 200 miles further north, on the same range, near Pike's Peak. This discovery was made known in 1858, and led the next year to a large emigration from the western states. The region is on the western borders of Kansas, about the heads of the Platte river, and about 700 miles west from

Leavenworth. Already several villages have been built up, and permanent settlements established, the importance of which is greatly enhanced by this being on the direct route from Missouri to San Francisco. So rapidly has this district been settled, that in July, 1860, a private mint was in operation at the so-called Denver City, Jefferson territory, converting the gold into coin, which formed the principal circulation of the country. For the first month, ending August 14, the coinage amounted to $18,065, the second month to $32,955, and the third, ending October 14, to $41,395, making a total of $92,415. Besides the amount coined, it is estimated by the firm of Clark, Gruber & Co., by whom this business was conducted, that at least thrice as much gold was offered at their counter and not purchased on account of the high rates demanded. The average fineness of the gold dust coined is 832-1000, making the average value of the bullion, or dust after melting into bars, $17.20 per ounce. The average per cent. of silver in the dust is 16½, and in the gold from the mills, 18, and the bullion obtained from the latter is worth only $16.90 per ounce. A number of mills are in operation, and their product, it is expected, will increase during the winter, as most of them are prepared to run in freezing weather; but the product of gold dust is diminishing. The largest piece of gold reported to be found in this district is worth $128. How much gold has been obtained from all the mines it is impossible to ascertain. There were transported to the east by the express of Messrs. Hinckley & Co., in July, August, and September, 1860, $110,269; but much more has probably been brought away by the returning miners.

The most important gold region of the United States and of the world is that of California. Its development has not only largely multiplied the previous gold production of the globe, but it has been the means of rapidly bringing into the use of civilized nations large territories of productive lands, which before were an unprofitable wilderness, founding new states, enlarging the commerce of the world, and bringing into closer intercourse nations which before were the most widely separated. At the period when the wealth of the gold mines of California began to be realized, the annual production of gold throughout the world had gradually fallen to about $20,000,000, and more than half of this was furnished by Russia alone. In 1853, only five years later, California produced an amount estimated at $70,000,000, and the total production, through the supplies, nearly as large, furnished at the same time by Australia, had increased to almost double this amount. Little was known of California previous to the discovery of gold at Sutter's mill, on the American fork of the Sacramento, in February, 1848; yet its being a country containing gold was made known by Hakluyt in his account of Drake's expedition of 1577–9, and by Cavello, a Jesuit priest of San José, Bay of Francisco, who published a work on the country in Spain in 1690. Reports from later travellers confirmed these statements at various times, and in *Hunt's Merchants' Magazine* for April, 1847, a report is presented by Mr. Sloat, which speaks in very decided terms of the richness of the gold placers of the country, as noticed by him during his observations of the two preceding years. The Rev. C. S. Lyman, in a letter written to the editor of the *American Journal of Science* from San José, in March 1848, notices the discovery of the preceding month as very promising. In August of that year it was reported that four thousand men were engaged in working the deposits on the American fork, and were taking out from $30,000 to $40,000 a day. This comprised a large portion of the population of California. San Francisco was almost deserted, and people were pouring in from distant regions. The next year the emigration commenced in the United States, both by sea around Cape Horn, and across the plains and Rocky Mountains in large parties. By the close of the year 1849 the number of persons engaged in mining was estimated at from 40,000 to 50,000 Americans, and about 5,000 foreigners: the total product of gold at about $40,000,000. The mining district was traced up the valley of the Sacramento toward the north, and the continuation of the same formations up that of the San Joaquin in the opposite direction was also beginning to be understood. Along the valleys of the streams, which flowed into these rivers from the Sierra Nevada range to the east, gold was almost everywhere found, and upon the hills and elevated plains it was met with beneath the sands and clays which covered the surface to the depth of fifteen to thirty feet or more; all the materials, earthy and metallic, appearing either to have been derived from the superficial disintegration of the slaty formations, or to have been depos-

ited by ancient rivers, which have since been diverted in other directions. Deposits of this character were called dry diggings, and, except in the wet season, were worked to great disadvantage for the want of water to separate the earthy matters from the gold. In the bottoms of the streams the deposits contained much coarse gold, derived from the wearing down of the slate formations through which they had made their way in their rapid descent from the Sierra Nevada mountains. By the excavation of the vast gulches or ravines of these streams, some of which presented precipitous walls of about 3,000 feet in height, an immense amount of gold must have been removed from its original beds, which, as the lighter earthy matters were swept down the rivers, remained behind, forming the riches of the auriferous deposits. The country of this peculiar character was found to extend along the western slopes of the Sierra Nevada for 400 or 500 miles, and the gold-bearing slates to spread over a width of from forty to sixty miles.

Whether or no the natural processes by which the gold had been collected from its original beds suggested to the California miner an improved method of washing the auriferous formations upon a gigantic scale, it was soon found that the richness of the deposits would justify, especially in the dry diggings, large outlays in conveying water from great distances by canals or ditches, and applying this, either under the pressure of a great head, to tear up the material from its bed and wash away the earthy portions, or to wash the auriferous gravels as these were carried to the water sluices and thrown into them for this purpose. On this plan, hydraulic operations were soon laid out of extraordinary extent. Currents were diverted well up the slope of the Sierra Nevada mountains, and conveyed in canals along the sides of the hills, and in sluices, supported upon trestle-work, from one hill to another, sometimes at a height of more than 200 feet above the bottoms. On the hills where the water was required for "hose washing," it was taken from the canal or sluice in a large and strong canvas hose, to the lower end of which a nozzle, like that of a fire engine, was attached. The least head for efficient service was about 60 feet, and a head of 100 feet was used where it could be had and the hose would bear it. Large hose and nozzles proved much more efficient than several smaller ones of equal or even greater capacity. As estimated by Mr. Wm. P. Blake, with a pipe of an inch and a half or two inches aperture, and a pressure of 90 feet head, a boy can excavate and wash as much auriferous earth as 10 or 15 men by the ordinary methods. In suitable places, where the waste water can flow rapidly away though the sluices made for its channel and for catching the gold, the jet of water is directed against the side of a hill, which it rapidly excavates, sweeping off the earthy portions, undermining the trees, and rolling down the loose stones, and, where the ground is favorable for the operation, cutting every thing away, it may be to a depth of 100 feet from the top to the bottom of the excavation, leaving behind barren acres of loose stone in unsightly piles—a perfect picture of desolation. At the close of the year 1858 it was estimated that the artificial water-courses already constructed for mining purposes in California amounted to 5,726 miles in length, and their cost to $13,575,400; and besides these there were branches not enumerated, and others in construction, to the extent of about 1,000 miles more. Among the principal of these canals are the Columbia and Stanislaus, in Tuolumne county, which is 80 miles long, and cost $600,000; the Butte, in Amador county, 50 miles long, cost $400,000; that of the Union Water Company, in Calaveras county, 78 miles long, cost $320,000; and that of the Tuolumne Hydraulic Company, 60 miles long, cost $300,000. Notwithstanding the cost of these enterprises, they have proved in general highly profitable, paying, after deducting the expenses of keeping them up, from one to more than five per cent. a month. The water is sold to the miners by the canal companies at so much per inch of the discharge—this being from a horizontal aperture, one inch high, at the bottom of a box in which the water is kept six inches deep. The length of the aperture is regulated by a slide. The price has fallen from $3.00 an inch per day in 1851, to 50 cents in 1854, and is now still less.

Sluice-washing, which is a necessary part of the hydraulic or hose process, is also carried on independently of it, and by a method which was first adopted in California. Channels are made sometimes upon the surface of the slaty beds in place, the ragged edges of which are very favorable for catching the gold, or sometimes of boards,

in the form of an open trough, a foot or 15 inches in width, and 8 or ten inches deep, which are extended to several hundred feet in length. These are set at a suitable slope, usually about one in twelve, and "riffle" bars are laid across to obstruct the flow of the heavy metallic particles which sweep along the bottom, while the muddy portions and stones are carried over with the flow of the water, and discharged at the lower end. Fresh gravel is continually shovelled into the sluices, and once a day, or oftener, these are cleaned up to collect the gold from the riffles and pools, which are sometimes used at the head of one joint of the sluice to receive the discharge from the next one above. Where the descent is rapid enough to keep the pool "in a boil," a considerable portion of the gold may be caught in it, especially if mercury be introduced.

In 1851 attention began to be turned to the quartz veins, or "ledges," as they were called, and numerous companies were soon established in the United States and in England for carrying on regular mining operations upon these. Within five years after, many deep shafts had been sunk upon veins in different parts of the country, and mills were in operation, furnished with the most efficient machinery for crushing and washing the ore. The uncertain supply of water, and the great expense attending the procuring it by canals from a distance, have operated strongly against the success of these works. They have, however, added considerably to the production of gold, and are still vigorously prosecuted. Upon the estate of Col. Fremont, in Mariposa county, several veins are worked to considerable extent on the northern ridge of Mount Bullion, and the quartz is transported to the Benton Mills, on Bear River, and to the steam mills at Bear Valley, Ophir, Guadaloupe, and Agua Fria. The principal vein, called the Pine Tree, has been traced about 20 miles from Mount Ophir, through Bear Valley, and along Mount Bullion to Merced River, with an average thickness of 30 feet. Among its contents are found oxides and carbonates of copper, and its ores are often exceedingly rich in gold. Those of the neighboring vein, called the Josephine, are variously valued at from $50 to $2,000 per ton. On account of the precipitous character of the hills, the transportation of the ore was almost impracticable until Col. Fremont had constructed a railroad, 3¾ miles long, down the steep slopes, in zigzag lines, upon grades varying from 2 to 7½ feet in 100, and with 17 curves of radii, varying from 53 to 84 feet. The width of the track is 36 inches, and the rails are of iron bars set on edge. The cars carry each 2½ tons of rock, and are run down in 45 minutes, their movement being regulated by a brake. By the construction of this road and the completion of new mills, furnished with powerful stamping machinery, and with inexhaustible supplies of ore at command, Col. Fremont is now in a position to thoroughly test the question as to the dependence that may be placed upon quartz mining in California as a permanent business.

The total production of the mines of California, as nearly as can be made up from the official returns, has been presented in the following values, in pounds sterling, for the years named:—

1848.....	£11,700	1853.....	£12,500,000
1849.....	1,612,000	1854.....	14,100,000
1850.....	5,000,000	1855.....	13,400,000
1851.....	8,250,000	1856.....	14,000,000
1852.....	11,700,000	1857.....	13,110,000

The quantities deposited in the mints of the United States will be given, together with those from other states, in the course of this article.

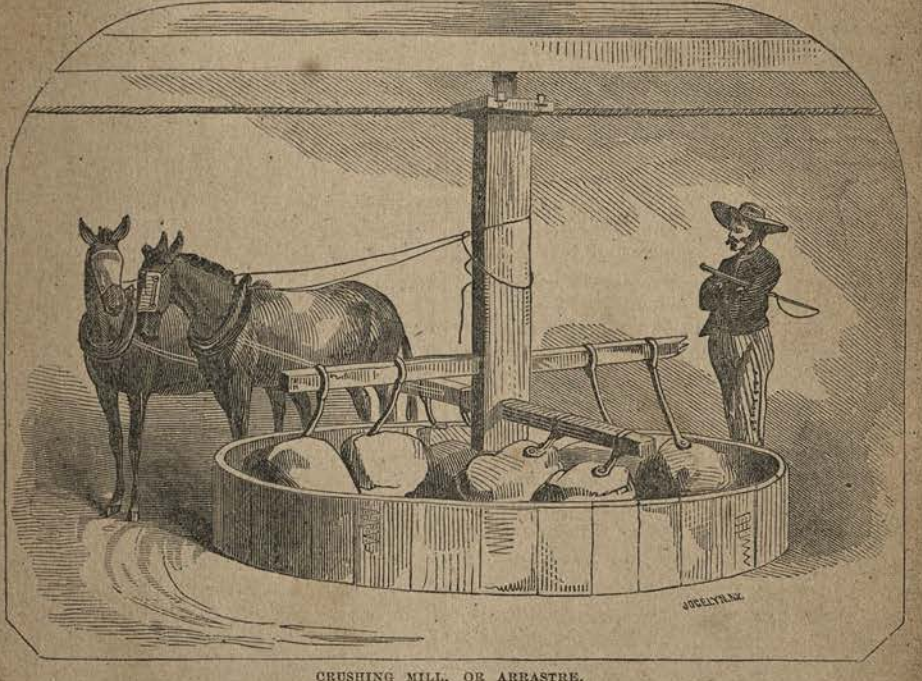
Gold is almost universally found native, or uncombined with other substances, and the processes for separating it from the stony matters with which it is associated may be, and commonly are, wholly mechanical. It occurs in the alluvial deposits, mixed with their lowest beds of sand and gravel; also in veins, usually of quartz, which often contain various metallic ores besides the gold; and it is disseminated through the mass of great beds of slate, which are frequently in a more or less decomposed condition. From such beds it is often distributed in fine particles through the soil in their vicinity. Not subject to be chemically affected by any of the ordinary agents of change, the particles of gold, large or small, remain unaltered in the soil, always seeking by their great weight the lowest level; and they may at any time be collected by washing away the earthy matters. New localities are tested by trying the earth in different places, by washing it in an iron pan or upon the blade of a shovel, an experienced hand readily throwing the heavy particles by themselves, while the lighter are allowed to flow away. This method is one of the

means in use for collecting gold upon a small scale, and the Mexicans of the gold regions, by long practice, are particularly expert in it. If a vein is to be tested, the quartz is finely crushed, and the powder is then washed in the same manner. Gold may be thus brought to view when none was visible in the stones, however closely examined. By placing a little mercury or quicksilver in the pan, the gold will be more perfectly secured, as, by coming in contact with each other, these metals instantly unite to form a heavy amalgam, and the mercury thus holds the finest particles of gold so that they cannot escape. The mixture, separated from the sand, is squeezed in a piece of thick linen or deerskin, through which the excess of mercury escapes, leaving the amalgam. This may then be heated on a shovel, when the mercury goes off in vapor, and the gold is left in its original-shaped particles, cohering together in a cake. If the quantity of amalgam is considerable, it is distilled in a retort, and the mercury is condensed to be used again. This amalgamation fails entirely if the slightest quantity of any greasy substance is present, as a film of the grease coats every portion of the mercury, and effectually prevents its contact with the gold. These processes contain the principles of nearly all the methods in use for separating gold. A great variety of machines have been based upon them, the simplest of which have proved the most valuable. The Burke rocker has always been a favorite machine in the southern states, and has been largely used in California by small companies of miners, and in localities where operations were not carried on upon a very extensive scale. It is a cradle-shaped trough, about six feet long, set on two rockers, the upper end a few inches higher than the lower, and placed so as to receive at its head a current of water from the end of a leading trough above. This falls upon a perforated iron plate, set as a shelf in the machine, and upon this the auriferous gravel is thrown. The finer particles fall through as the rocker is kept in motion by hand, and the coarse gravel rolls down to the lower end, and falls off upon the ground. Across the bottom of the rocker are placed, at intervals of 6 or 8 inches, low bars or partitions which catch the heavy sands, and prevent their being washed out of the lower end with the water and mud. This lower portion is sometimes arranged as a drawer, which can be secured by a lock, so that the gold which falls into it is safe against robbery. The drawer is called the "riffle box." Some rockers are mere open troughs without a shelf. The "tom" is often preferred to the rocker, which it resembles, except in its being a trough without rockers, on the plan of the sluices already described. Both it and the rocker are of convenient size for moving about from one place to another, as the working of the deposit advances.

BURKE ROCKER.

Vein mining requires more efficient machinery, and stamping mills are constructed as near as may be to the mines, for reducing the stony materials to powder, and the sands from the stamps are passed through a variety of machines designed to catch the gold. Stamps are solid blocks of the heaviest cast iron attached to the end of a wooden or iron rod called the leg, to which the lifting cam is applied for raising them. They commonly weigh about 300 lbs. each, though in California they are made of twice and even three times this weight. Several of them are set together in a frame side by side, and are lifted in succession by the cams upon a horizontal shaft, which revolves in front of them. The bed in which they stand, and into which the ore to be crushed is thrown, is sometimes a massive anvil, hollow in the top, firmly imbedded in a heavy stick of timber, or is formed of stones, beaten by the stamps themselves into a solid bed. Water is usually supplied in small currents to the stamps; and sometimes mercury also is poured into the bed. The only exit for the crushed materials is through small holes punched in a sheet of copper, of which the

side of the boxing around the stamps is formed, opposite to that at which the ore is fed. Through these holes the mud and water are projected with every blow into a capacious box, the floor of which inclines gently back toward the stamp, and contains along this edge a quantity of mercury, in which a considerable portion of the gold is caught. From the box a spout leads the current into the other machines, often through an inclined trough, in the bottom of which baize or blanket stuff is laid for the purpose of entangling in its fibres the particles of gold that are swept along. These are frequently taken up and cleaned. Much of the gold, however, always escapes them, and the current is variously treated before it is finally allowed to flow away. The sands require to be more finely pulverized, and the current first flows into mills of some sort, as the Chilian mill, arrastre, etc. The former consists of a pair of heavy wheels of granite, from four to six feet in diameter when new, set in a horizontal frame, one on each side of an upright shaft, and carried around with the shaft as it revolves upon its axis. The stones



CRUSHING MILL, OR ARRASTRE.

being as close as possible to the shaft, have a twisting motion which acts powerfully to grind the particles crushed by their weight. They revolve in a water-tight box or tub upon a granite floor. Sometimes they are used in the place of stamps for breaking up the coarse ore; and worked at the rate of eight to twelve revolutions a minute, they should crush to fine sand from one to two tons of quartz in twelve hours. The water, which flows in one side the tub, passes out over the opposite edge with the light slime and fine mud, while much of the gold remains in the bottom, caught by the mercury placed there to secure it. The arrastre is something like the Chilian mill, only instead of revolving stones, heavy flat ones are dragged round with the shaft by chains, secured to the horizontal arms. These machines in Mexico are worked by horses or mules, but in this country by water or steam power. The slowness of their operation is not regarded as an objectionable feature, but on the contrary is favorable for effectually securing the gold. Among the simplest and best contrivances employed below the Chilian mill are the "shaking tables." These are platforms seven or eight feet long, of plank in a single piece, as wide as can be procured. The planks, of two inches thickness, are worked down from a line across the middle to a thin edge at one end, and from the other

end they are made to diminish to half an inch thickness at the line across the middle. Each one is furnished with sides, and a strip across the thin end of six inches in height, the joining made perfectly tight, and is then swung between four posts in a horizontal position by four rods or chains, which should be at least eight feet long. Mercury is poured into the two divisions, until they are more than half filled. The sands are made to flow in upon the thin end, and are received upon the face of the mercury; and the table is made to swing forward and back by the revolution of a crank. By the motion the sands are mixed in with the mercury, and swept along in successive waves, and falling over the middle ridge are treated in the same manner in the succeeding division. The mercury is retained by its weight in the depressed portions of the table, and the water and sands are discharged over the open end. Many machines designed for effecting the amalgamation of the gold in the most thorough manner have been patented within the last few years, and have been introduced at the mines under various names; few of them, however, involve any new principles, but are merely modified forms of the old contrivances. The use of hot water was found several years ago to hasten the amalgamation, and the employment of steam engines provided a cheap way of obtaining it in the large quantities required. Prof. A. K. Eaton, of New York, found that amalgamated metallic surfaces could be made to collect most completely the very fine particles of gold, which by all other processes it has been found impossible to secure. The use of copper, brass, or zinc proved troublesome and impracticable from the rapidity with which they were dissolved in the mercury, adulterating the amalgam. An amalgamated iron surface proved to be free from this objection, and the following description of apparatus was finally decided on as the most efficient: A circular plate of wrought iron is amalgamated over what is intended to be its inferior surface, and an open tube is fixed in its centre, rising three or four feet high, and furnished at the top with a bowl or funnel. This tube and disk are supported upon a surface of mercury contained in a shallow tub of larger diameter than the disk, a frame-work being attached to the tub for this purpose. A pulley is fixed upon the hollow shaft, so that a belt may be attached for causing the disk to rotate upon the mercury. The sands are fed with water into the funnel at the top of the tube, and the pressure caused by the height of the column carries them down upon the mercurial surface, and, by reason of this pressure and the centrifugal action of the revolving disk, they gradually work outward between this surface and the amalgamated surface above, being pressed and rubbed between them till they escape round the circumference of the disk, and flow over the edge of the tub. Hot water, as in all other modes of amalgamating, is preferable to cold. By this process all free gold, however fine the particles, must come in contact with the amalgamated surface, and be taken up by the mercury. It perfectly separates the gold that in other machines floats off in the fine slime, for the reason that simply pressed into the mercury and left to themselves, the impalpable particles immediately rise upon its surface, without coming into actual contact with the fluid metal. In gold ores, especially those of sulphurous character, much of the gold is so fine that it remains suspended a long time in water, and is entirely lost. The important feature of this invention is the use of an inferior amalgamated surface, against which these floating particles are pressed. The pressure is secured by any desired depth of the mercury, but in practice less than an inch above the lower edge of the plate is found to be sufficient. The efficiency of the machine was fully tested in November, 1860, at the Gold Hill mine, in North Carolina, where better results were obtained with it than by any other machine ever before applied to the separation of the gold from its pyritous sands. In the same month it was tried at the United States assay office, in New York city, upon the tailings of the sweeps from which all the gold had been extracted that could be removed by the amalgamating machines in use, and from these it readily separated the remaining portion.

As remarked in the mention made of the Gold Hill mines, when gold is associated with iron and copper pyrites it is held very tenaciously, as if combined itself with the sulphur, like the other metals. However finely such ores are pulverized, every microscopic particle of pyrites appears to retain a portion of gold, and prevent its uniting with the mercury. This portion of the gold, consequently, escapes in the tailings; and if these are kept in refuse heaps, exposed to the weather, the pyrites slowly decompose,

and more gold is continually set free. Thus it is the heaps may be washed over with profit for many successive years. Artificial roasting of the ores is recommended by high authorities as a sure method of freeing the gold at once, the effect of it being to break up the sulphurets, causing the sulphur to escape in vapor, and the iron to crumble down in the state of an oxide, or an ochreous powder, from which the gold is readily separated by the ordinary methods. This is objected to by others, who assert that it involves a great loss of gold, which is volatilized or carried off mechanically in the sulphur fumes. In California complete separation is sought to be attained by long-continued and most thorough pulverization of the ores, the heavy sands of the first concentration being received into Chilian or other mills, and repeatedly ground to the extreme of fineness, and always in the presence of mercury. Various chemical processes have been devised for the treatment of these ores, and in Russia it has been proposed to smelt the sands after they had been concentrated, and cause the gold to be taken up by iron reduced by the same smelting operation from its ores. The mechanical and amalgamating treatment, however, appears to be the only one in successful use.

The great value of gold renders it profitable to work deposits and ores which contain an exceedingly small per-centage of metal. In the "branch mining" of the southern states, deposits worked by the rocker are regarded as profitable which pay a pennyweight or nearly one dollar per day to the hand employed. The yield is always uncertain, and sometimes runs up, for a short time, to very large amounts; but it has, for the most part, ceased to be followed as a regular pursuit. The production of the ores is quite as uncertain as that of the deposits, and their value depends upon a variety of circumstances: as the hardness of the material, the tenacity with which it holds the fine gold when crushed, the convenience of the locality to mills, and the expenses attending the working of the mines. The great beds of decomposed slates of Georgia can be worked to profit when they yield from four to five cents worth of gold to the bushel of stuff, or about 100 lbs. weight; but the mill for crushing and washing it must then be close at hand. The proportion of the gold, in this case, is less than 2 parts in 1,000,000. The hard quartz ores must contain nearly or quite 20 cents worth of gold in the bushel, especially if they are pyritiferous.

Although the gold is obtained in a metallic state, it differs very much in value in different localities. That of the deposits is the proper representative of the character of the gold of any district, and always brings a higher price at the mint than the imperfectly cleaned gold derived from the veins of the same locality. It has peculiarities in its appearance by which its source may often be recognized. This is commonly owing to the different proportions of silver with which it is alloyed. Deposit gold from the vicinity of Dahlonega, in Georgia, is worth 93 cents the pennyweight; that of Hart county, in the same state, 98 cents; of Carroll county, Georgia, and Chesterfield district, South Carolina, $1.02; of Union county, Georgia, or the Tennessee line, 72 cents; Charlotte, North Carolina, $1.00; and that of Burke county, North Carolina, only 50 cents. The value appears to decrease toward the western margin of the gold region. The average fineness of California gold is found to be from 875 to 885 parts in 1,000, which is very near that of our gold coin, viz., 900 in 1,000. The native gold from Australia has from 960 to 966 parts in 1,000 pure gold, and some from the Chaudiere, in Canada, 877.3 pure gold, and 122.3 silver; another specimen 892.4, silver 107.6. The specific gravity of the metal has been increased by casting from 14.6 in the native state to 17.48.

At the mint and branch mints of the United States, records are preserved of the source whence the gold offered for coinage is obtained, and tables are thus prepared, copies of which are given on the succeeding pages. These are interesting for reference, although they can hardly be regarded as presenting even an approximate estimate of the amount of gold derived from the mines of the United States. As already stated, considerable portions of this never reach the mints; and from California particularly large quantities have been carried to Europe in the form of gold dust. The product of its mines is more nearly presented in the tables accompanying the description of the gold-mining operations of that region. Gold has been coined at private mints in California and at Pike's Peak; but this coinage, not recognized by the government, after circulating for a time, finds its way to the government mint, and the gold is credited in the accounts as the production of the region where it was converted into coin.

1.—MINT OF THE UNITED STATES, PHILADELPHIA.

Period.	Virginia.	North Carolina.	South Carolina.	Georgia.	Tennessee.	Alabama.	New Mexico.	California.	Oregon.	Kansas.	Other sources.	Total.
1804 to 1827	..	$110,000 00	..	..	..	..	..	..	..	..	..	$110,000 00
1828 to 1837	$427,000 00	2,519,500 00	$327 500	$1,763,900 00	$12,400	..	..	..	..	..	$13,200	5,063,500 00
1838 to 1847	518,294 00	1,303,636 00	152,366	566,316 00	16,499	$45,493	..	..	..	..	21,037	2,623,641 00
1848	57,886 00	109,034 00	19,228	3,370 00	3,497	3,670	$682	$44,177 00	..	..	..	241,544 00
1849	129,382 00	102,688 00	4,309	10,525 00	2,739	2,977	32,889	5,481,439 00	..	..	144	5,767,092 00
1850	65,991 00	43,734 00	759	5,114 00	307	1,178	5,392	31,667,505 00	..	..	326	31,790,306 00
1851	69,052 00	49,440 00	12,338	2,490 00	126	817	890	46,939,367 00	..	..	..	47,074,520 00
1852	83,626 00	65,248 00	4,505	3,420 00	..	254	814	49,663,623 00	..	..	..	49,821,490 00
1853	52,200 00	45,690 00	3,522	1,912 00	..	..	3,632	52,732,227 00	13,535	..	5,213	52,857,931 00
1854	23,347 00	9,062 00	1,220	7,561 00	..	245	738	35,671,185 00	..	..	..	35,713,358 00
1855	28,895 50	22,626 00	1,200	1,733 50	..	310	900	2,634,297 63	..	..	1,535	2,691,497 63
1856	21,607 00	12,910 00	5,980	4,910 00	..	..	2,460	1,440,134 58	40,750	..	..	1,528,751 58
1857	2,505 00	6,805 00	2,565	3,542 00	..	..	..	565,566 41	..	..	..	580,983 41
1858	18,377 00	15,175 00	300	18,365 00	..	..	..	1,372,506 07	3,600	..	..	1,428,323 07
1859	15,720 00	9,305 00	4,675	20,190 00	240	..	275	959,191 79	2,960	$145	..	1,012,701 79
Total	$1,513,882 50	4,424,853 00	540,467	2,413,348 50	35,808	54,944	48,672	229,171,219 48	60,845	145	41,455	238,305,639 48

2.—BRANCH MINT, SAN FRANCISCO.

Period.	California.	Period.	California.	Period.	California.
1854	$10,842,281 23	1856	29,209,218 24	1858	19,104,369 99
1855	20,860,437 20	1857	12,526,826 93	1859	14,098,564 14
		Total			$106,641,697 73

3.—BRANCH MINT, NEW ORLEANS.

Period.	North Carolina.	South Carolina.	Georgia.	Tennessee.	Alabama.	California.	Other sources.	Total.
1838 to 1847	$741	$14,306	$37,364	$1,772 00	$61,903	..	$3,613	$119,699 00
1848	..	1,488	2,317	947 00	6,717	$1,124 00	..	12,593 00
1849	..	423	..	..	4,062	669,921 00	2,733	677,189 00
1850	..	..	..	..	3,560	4,575,576 00	894	4,580,030 00
1851	..	..	..	..	1,040	8,764,682 00	..	8,770,772 00
1852	..	..	..	..	..	3,777,784 00	..	3,777,784 00
1853	..	..	..	..	..	2,006,673 00	..	2,006,673 00
1854	..	..	..	..	..	981,511 00	..	981,511 00
1855	..	..	..	..	..	411,517 24	..	411,517 24
1856	..	..	..	..	..	283,344 91	..	283,344 91
1857	..	..	..	..	..	129,328 39	..	129,328 39
1858	..	..	1,560	164 12	..	448,439 84	..	450,163 96
1859	..	..	..	..	..	93,272 41	..	93,272 41
Total	$741	16,217	41,241	2,883 12	77,282	22,148,173 79	7,290	22,293,827 91

4. BRANCH MINT, CHARLOTTE, NORTH CAROLINA.

Period.	N. Carolina.	S. Carolina.	California.	Total.	Period.	N. Carolina.	S. Carolina.	California.	Total.
1838 to 1847....	$1,529,777 00	$143,941 00	..	$1,673,718 00	1854.....	$188,277 00	$19,006 00	$6,328 00	$213,606 00
1848.....	359,075 00	11,710 00	..	370,785 00	1855.....	196,894 03	14,277 17	5,817 66	216,988 86
1849.....	378,223 00	12,509 00	..	390,732 00	1856.....	157,355 18	..	16,237 35	173,592 53
1850.....	307,289 00	13,000 00	..	320,289 00	1857.....	170,560 33	5,807 16	..	176,067 49
1851.....	275,742 00	25,478 00	$15,111 00	316,061 00	1858.....	75,376 47	..	..	75,376 47
1852.....	337,604 00	64,934 00	28,362 00	430,900 00	1859.....	182,489 61	22,762 71	..	205,252 32
1853.....	227,847 00	61,845 00	15,465 00	305,157 00					
Total.....						$4,386,239 62	$394,965 04	$87,321 01	$4,868,525 67

5. BRANCH MINT, DAHLONEGA, GEORGIA.

Period.	N. Carolina.	S. Carolina.	Georgia.	Tennessee.	Alabama.	California.	Kansas.	Other sources.	Total.
1838 to 1847..	$64,351 00	$99,427 00	$2,978,353 00	$32,175 00	$47,711 00	..	..	..	$3,218,017 00
1848.....	5,434 00	8,151 00	251,376 00	2,717 00	4,075 00	..	..	..	271,753 00
1849.....	4,882 00	7,323 00	225,824 00	2,441 00	3,661 00	..	..	..	244,131 00
1850.....	4,500 00	5,700 00	204,473 00	1,200 00	1,800 00	$30,025 00	..	..	247,698 00
1851.....	1,971 00	3,236 00	154,723 00	2,251 00	2,105 00	214,072 00	..	$951 00	379,309 00
1852.....	343 00	57,543 00	93,122 00	750 00	..	324,931 00	..	..	476,789 00
1853.....	2,085 00	33,950 00	56,984 00	149 00	..	359,122 00	..	..	452,290 00
1854.....	5,818 00	15,988 00	47,027 00	223 00	..	211,169 00	..	..	280,225 00
1855.....	3,145 82	9,113 27	56,686 36	..	277 92	47,428 70	..	..	116,652 07
1856.....	..	25,723 75	44,107 99	106 42	..	31,467 10	..	..	101,405 26
1857.....	..	8,088 89	25,097 63	..	..	6,498 42	..	..	39,679 54
1858.....	..	32,322 28	57,891 45	107 33	..	5,293 52	..	..	95,614 58
1859.....	2,656 88	4,310 35	57,023 12	..	..	699 19	$82 70	..	65,072 24
Total.....	$95,286 70	$307,171 54	$4,252,688 55	$42,119 75	$59,629 92	$1,230,705 53	$82 70	$951 00	$5,988,685 69

6. ASSAY OFFICE, NEW YORK.

Period.	Virginia.	N. Carolina.	S. Carolina.	Georgia.	Alabama.	California.	Kansas.	Oregon.	Other sources.	Total.
1854.....	$167 00	$3,916 00	$395 00	$1,242 00	..	$9,221,457 00	..	..	..	$9,227,177 00
1855.....	2,370 00	3,750 00	7,620 00	13,100 00	$350 00	25,025,896 11	..	..	$1,600 00	25,054,686 11
1856.....	6,928 00	805 07	4,052 29	41,101 28	233 62	16,259,008 90	..	..	..	16,582,129 16
1857.....	1,531 00	1,689 00	2,663 00	10,451 00	1,545 00	9,899,957 00	..	..	..	9,917,836 00
1858.....	501 00	7,007 00	6,354 00	12,951 00	2,181 00	19,660,551 46	..	$5,581 00	27,523 00	19,722,629 46
1859.....	436 00	20,122 00	700 00	14,756 00	593 00	11,694,872 25	$3,944 00	2,866 00	405 00	11,738,694,25
Total.....	$11,933 00	$37,289 07	$21,784 29	$93,601 28	$4,902 62	$92,031,722 72	$3,944 00	$8,447 00	$29,528 00	$92,243,151 98

7. SUMMARY EXHIBIT OF THE ENTIRE DEPOSITS OF DOMESTIC GOLD AT THE UNITED STATES MINT AND BRANCTES, TO JUNE 30, 1859.

Mints.	Virginia.	N. Carolina.	S. Carolina.	Georgia.	Tennessee.	Alabama.	New Mexico.	California.	Kansas.	Oregon.	Other sources.	Total.
Philadelphia.....	$1,513,582 50	$4,424,853 00	$540,467 00	$2,413,348 50	$35,808 00	$54,944 00	$48,672 00	$229,171,219 48	$145 00	$60,845 00	$41,455 00	$238,305,639 48
San Francisco...	..	..	..	..	..	..	..	106,641,697 73	..	..	..	106,640,697 73
New Orleans....	..	741 00	16,217 00	41,241 00	2,883 12	77,282 00	..	22,148,173 79	..	..	7,290 00	22,293,827 91
Charlotte.....	..	4,386,239 62	394,965 04	..	..	..	..	87,321 01	..	..	..	4,868,525 67
Dahlonega.....	..	95,286 70	307,171 54	4,252,688 55	42,119 75	59,629 92	..	1,230,705 53	82 70	..	951 00	5,988,635 69
Assay Office.....	11,933 00	37,289 07	21,784 29	93,601 28	..	4,902 62	..	92,031,722 72	3,944 00	8,447 00	29,528 00	92,243,151 98
Total.....	$1,525,515 50	$8,944,409 39	$1,280,604 87	$6,800,879 33	$80,810 87	$196,758 54	$48,672 00	$451,310,840 26	$4,171 70	$69,292 00	$79,224 00	$470,340,478 46

The most important use of gold is as a medium of exchange. For this purpose it is converted into coin at the mints, and into bars or bullion at the government assay office. In this form a large portion of the receipts from California is immediately exported from New York to make up the balance of foreign trade. Each bar is stamped with marks, representing its fineness and weight, and may continue to be thus used, or when received at foreign mints, is converted into coin. A large amount of gold is consumed in jewelry, trinkets, watches, and plate, and still more in the form of gold-leaf. This last being worn out in the using, or being distributed in too small quantities together to pay for recovering it, is altogether lost to the community, after the articles have served the purpose intended. This loss in the time of James I. was considered so serious, that a special act was passed, restricting the use of gold and silver-leaf, except for specified objects, which, singularly enough, were chiefly for military accoutrements. Gold employed in the recently invented process of electrotyping, in which large quantities are consumed, is similarly lost in the using.

Besides the use of gold-leaf in gilding, it is employed quite largely by dentists as the best material for filling teeth. They also use much gold plate and wire for securing the artificial sets in the mouth. In bookbinding, gold is consumed to considerable extent for lettering and ornamenting the backs of the books. The manufacture of gold-leaf is carried on in various places, both in the cities and country. It is a simple process, known in ancient times, but only of late years carried to a high degree of perfection. The ingots, moulded for the purpose, and annealed in hot ashes, are rolled between rollers of polished steel, until the sheet is reduced from its original thickness of half an inch to a little more than $\frac{1}{800}$ of an inch, an ounce weight making a strip ten feet long and 1½ inches wide. This is annealed and cut into pieces an inch square, each weighing about six grains. A pile is then made of 150 of these pieces, alternating with leaves of fine calf-skin vellum, each one of which is four inches square, and a number of extra leaves of the vellum are added at the top and bottom of the pile. The heap, called a tool or kutch, is slipped into a parchment case open at the two ends, and this into a similar one, so that each side of the pack is protected by one of the case. It is placed upon a block of marble, and then beaten with a hammer weighing sixteen pounds, and furnished with a convex face, the effect of which is to cause the gold to spread more rapidly. The workman wields this with great dexterity, shifting it from one hand to the other, without interfering with the regularity of the blow. The pack is occasionally turned over, and is bent and rolled in the hands to cause the gold to extend freely between the leaves, as it is expanded. The gold-leaves are also interchanged to expose them all equally to the beating. When they have attained the full size of the vellum, which is done in about twenty minutes, they are taken apart, and cut each one into four pieces, making 600 of the original 150. These are packed in gold-beater's skin, and the pack is beaten as before, but with a lighter hammer, until they are extended again to sixteen square inches. This occupies about two hours. The gold-leaves are then taken out, and spread singly upon a leather cushion, where they are cut into four squares by two sharp edges of cane, arranged in the form of a cross. To any other kind of a knife the gold would adhere. These leaves are again packed, 800 together, in the finest kind of gold-beater's skin, and expanded till each leaf is from 3 to 3½ inches square. The aggregate surface is about 192 times larger than that of the original sheet, and the thickness is reduced to about the $\frac{1}{1500000}$ of an inch. The beating is sometimes carried further than this, especially by the French, so that an ounce of gold is extended over 160 square feet, and its thickness is reduced to $\frac{1}{2340000}$ of an inch, or even to $\frac{1}{2500000}$. When the pack is opened, the leaves are carefully lifted by a pair of wooden pliers, spread upon a leather cushion by the aid of the breath, and cut into four squares of about 3¼ inches each, which are immediately transferred one by one between the leaves of a little book of smooth paper, which are prevented from adhering to the gold-leaves by an application of red ochre or red chalk. Twenty-five leaves are put into each book, and when filled, it is pressed hard, and all projecting edges of the gold are wiped away with a bit of linen. The books are then put up in packages of a dozen together for sale.

An imitation gold-leaf, called Dutch gold-leaf, is used to some extent. It is prepared from sheets of brass, which are gilded, and

beaten down in the manner already described. When new it appears like genuine gold-leaf, but soon becomes tarnished in use. Party gold-leaf is formed of leaves of gold and of silver, laid together and made to unite by beating and hammering. It is then beaten down like gold-leaf.

The gold-beater's skin used in this manufacture is a peculiar preparation made from the cæcum of the ox. The membrane is doubled together, the two mucous surfaces face to face, in which state they unite firmly. It is then treated with preparations of alum, isinglass, whites of eggs, etc., sometimes with creosote, and after being beaten between folds of paper to expel the grease, is pressed and dried. In this way leaves are obtained $5\frac{1}{2}$ inches square, of which moulds are made up, containing each 850 leaves. After being used for a considerable time, the leaves become dry and stiff, so that the gold cannot spread freely between them. To remedy this, they are moistened with wine or with vinegar and water, laid between parchment, and thoroughly beaten. They are then dusted over with calcined selenite or gypsum, reduced to a fine powder. The vellum, which is used before the gold-beater's skin, is selected from the finest varieties, and this, too, after being well washed and dried under a press, is brushed over with pulverized gypsum.

In the great exhibition at London in 1851, machines were exhibited from the United States, and also from Paris, which were designed for gold-beating, and it was supposed they would take the place of the hand process. They have been put into operation at Hartford, in Connecticut, but after being tried, they have been laid aside for the old method.

CHAPTER IV.

LEAD.

Lead is met with in a great number of combinations, and has also been found in small quantity, at a few localities in Europe, in a native state. The common ore, from which nearly all the lead of commerce is obtained, is the sulphuret, called galena, a combination of 86.55 per cent. of lead and 13.45 of sulphur. It is a steel gray mineral of brilliant metallic lustre when freshly broken, and is often obtained in large cubical crystals: the fragments of these are all in cubical forms. The ore is also sometimes in masses of granular structure. Very frequently galena contains silver in the form of sulphuret of that metal, and gold, too, has often been detected in it. The quantity of silver is estimated by the number of ounces to the ton, and this may amount to 100 or 200, or even more; but when lead contains three ounces of silver to the ton this may be profitably separated. Ores of this character are known as argentiferous galena; if the silver is more valuable than the lead they are more properly called silver ores. In Mexico and Germany such are worked, but not in the United States. Galena is easily melted, and in contact with charcoal the sulphur is expelled and the lead obtained. The ore is found in veins in rocks of different geological formations, as in the metamorphic rocks of New England, the lower silurian rocks of Iowa, Wisconsin, and Missouri, in limestones and sandstones of later age in New York and the middle states, belonging to higher groups of the Appalachian system of rocks, and in the new red sandstone of Pennsylvania at its contact with the gneiss.

Carbonate of lead is another ore often associated with galena, though usually in small quantity. It is of light color, whitish or grayish, commonly crystallized, and in an impure form is sometimes obtained in an earthy powder. At St. Lawrence county, New York, large quantities of it have been collected for smelting, and were called lead ashes. The ore may escape notice from its unmetallic appearance, and at the Missouri mines large quantities were formerly thrown aside as worthless. It contains 77.5 per cent. of lead combined with 6 per cent. of oxygen, and this compound with 16.5 per cent. of carbonic acid. Beautiful crystals of the ore, some transparent, have been obtained at the mines on the Schuylkill, near Phœnixville, Pennsylvania; the Washington mine, Davidson county, North Carolina; and Mine La Motte, Missouri.

Another ore, the phosphate or pyromorphite, has been known only as a rare mineral until it was produced at the Phœnixville mines so abundantly as to constitute much the larger portion of the ores smelted. It is obtained in masses of small crystals of a green color, and sometimes of other shades, as yellow, orange, brown, etc., derived from the minute portions of chrome in combination. With these a variety of other compounds of

lead are mixed, together with phosphate of lime and fluoride of calcium, so that the percentage of the metal is variable. The compounds of lead met with at these mines are the sulphuret, sulphate, carbonate, phosphate, arseniate, molybdate, chromate, chromo-molybdate, arsenio-phosphate, and antimonial argentiferous. Besides all these, a single vein contained native silver, native copper, and native sulphur, three compounds of zinc, four of copper, four of iron, black oxide of manganese, sulphate of barytes, and quartz.

The eastern portion of the United States is supplied with lead almost exclusively from Spain and Great Britain, but the western states are furnished with this metal from mines in Iowa, Wisconsin, and Missouri. The lead veins of the eastern and southern states are of little importance. In Maine the ores are found in Cobscook Bay, near Lubec and Eastport; in limestone rocks near dikes of trap. A mine was opened in 1832, and a drift was carried in about 155 feet at the base of a rocky cliff on the course of the vein; it was then abandoned, but operations have recently been recommenced. In New Hampshire argentiferous galena is found in numerous places, but always in too small quantity to pay the expenses of extraction. At Shelburne a large quartz vein was worked from 1846 to 1849, and three shafts were sunk, one of them 275 feet in depth. The ore was found in bunches and narrow streaks, but in small quantity. Some of it was smelted on the spot, and five tons were shipped to England, which sold for £16 per ton. The richest yielded 84 ounces of silver to the ton. Another vein of argentiferous galena has been partially explored at Eaton, and this is most likely of any to prove valuable.

Massachusetts, also, contains a number of lead veins, none of which have proved profitable, though some of them have been worked to considerable extent. The most noted are those of Southampton and Easthampton. Operations were commenced at the former place in 1765 upon a great lode of quartz containing galena, blende, copper pyrites, and sulphate of barytes. It is in a coarse granitic rock near its contact with the red sandstone of the Connecticut valley. About the year 1810 an adit level was boldly laid out to be driven in from 1,100 to 1,200 feet, to intersect the vein at 140 feet below the surface. A single miner is said to have worked at it till his death, in 1828, when it had reached the length of 900 feet. At different times this adit has been pushed on, and when last abandoned, in 1854, it was supposed to be within a few feet of the vein. The rock was so excessively hard that the cost of driving the adit was about $25 per foot. Lead veins are found in Whately, Hatfield, and other towns in Hampshire county.

In Connecticut, also, several veins have been worked to some extent. That at Middletown, referred to in the introductory remarks as one of the earliest opened mines in the United States, is the most noticeable. It is unknown when this mine was first worked. In 1852 operations were renewed upon it, and a shaft sunk 120 feet below the old workings. The vein is among strata of a silicious slate, in some places quite rich, but on the whole it has proved too poor to work. The ore contained silver to the value of from $25 to $75 to the ton of lead.

Lead mines have been opened in New York, in Dutchess, Columbia, Washington, Rensselaer, Ulster, and St. Lawrence counties. In the first four of these the ore is found in veins near the junction of the metamorphic slates and limestones. The Ancram or Livingston mine, in Columbia county, has been worked at different times at considerable expense, but with no returns. A mine in Northeast, Dutchess county, was first opened by some German miners in 1740, and ore from it was exported. The Committee of Public Safety, during the revolutionary war, sought to obtain supplies of lead from it. The lead veins of this part of New York have attracted more interest, on account of their highly argentiferous character, than the quantity of ore they promise would justify; but it seems to be almost universally the case throughout the United States that the galena yielding much silver fails in quantity. The Ulster county mines are found on the west side of the Shawangunk mountain in the strata of hard grit rock which cover its western slope. At different places along this ridge veins have been found cutting across the strata in nearly vertical lines, and have produced some lead, zinc, and copper. The Montgomery mine, near Wurtsboro, in Sullivan county, was chiefly productive of zinc. Near Ellenville, Ulster county, several veins have been followed into the mountain, and one of these, which was worked in 1853, afforded for a short time considerable quantities of rich lead and copper ores. From the former there were smelted about 459,000 pounds of lead, and the sales of the latter

amounted to from 60 to 70 tons, of which 50 tons yielded 24.3 per cent. of copper. Where the vein was productive it contained the rich ores unmixed with stony gangues, and sometimes presenting a thickness of five feet of pure ore; where it became poor it closed in sometimes to a mere crack in the grit rock, and then the expense of extending the workings became very great from the extreme hardness of this rock. Open fissures were met with, one of which was more than 100 feet long and deep, and in places 12 feet or more wide. It was partially filled with tough yellow clay, through which were dispersed fragments of sandstone, magnificent bunches of quartz crystals, and lumps of lead and copper ores. The walls on the sides also presented a lining in places of the same ores. A drift was run into the base of the mountain about 200 feet, and a shaft was sunk at the foot of the slope about 100 feet. The expense of working in the hard rock proved to be too great for the amount of ore obtained, and the mine was abandoned in 1854, although its production, for the extent of ground opened, has been exceeded by but few other mines in the eastern states. The most promising veins in the state are those of St. Lawrence county in the vicinity of Rossie. They occur in gneiss rock, which they cut in nearly vertical lines. One of these was opened along the summit of Coal Hill, and was worked in 1837 and 1838 by an open cut of 440 feet in length, to the depth, in some places, of 180 feet. In 1839 the mine was abandoned, after the company had realized about $241,000 by the sale of some 1,800 tons of lead they had extracted. The galena was remarkably free from blende, and from pyritous iron and copper, which (especially the first-named) are so often associated with the ore, rendering it difficult to smelt. Calcareous spar, often finely crystallized, formed the gangue of the vein. A nearly transparent crystal, weighing 165 lbs., is preserved in the cabinet of Yale College. Other attempts have been made to work the mine; and the cause of its being allowed to lie idle appears to be the difficulty of negotiating a mining right with the proprietors.

In Pennsylvania the most productive lead mines are those of Montgomery and Chester counties, found in a small district of 5 or 6 miles in length by 2 or 3 in width, at the line of contact of the gneiss, and red shale and sandstone. About 12 parallel veins have been discovered, extending north 32° to 35° east, and dipping steeply south-east. In the gneiss they are productive in lead ores, and in the red shale in copper. The gneiss is decomposed, and the vein itself is in considerable part ochreous and earthy, owing to decomposition of pyritous ores. In this material, called by the miners gossan, silver has been discovered amounting to 10 ounces to the ton. The two principal mines of this group are the Wheatley and the Chester County. The former was opened in 1851, and up to September, 1854, had produced 1,800 tons of ore, principally phosphate, estimated to yield 60 per cent. of metal. In this vein the great number of varieties of lead and other ores enumerated above were met with. The Chester County Mining Company commenced operations in 1850, and up to November, 1851, had raised and smelted 190,400 lbs. of ore, almost exclusively phosphate, which produced about 47 per cent. of lead. The silver in this ore amounted to about 1.6 ounce in 2,000 lbs.; in the galena associated with it the silver was found in quantities varying from 11.9 to 16.2 ounces; the coarser grained galena giving the most, and the fine grained the least. In connection with the furnaces for smelting the ores, was one for separating the silver by cupellation, and a considerable amount of silver was obtained before the mining operations were abandoned, in 1854.

Lead ores are found along the Blue Ridge, in Virginia, and at one point, near the central portion of its range across the state, a mine has been worked for a number of years. They are also met with in several of the gold mines, but not in workable quantities. In south-west Virginia and east Tennessee the ores are found in the silurian limestones, and a considerable number of mines have been worked to moderate extent in both states. The most important one is the Wythe lead mine, 16 miles from Wytheville, which was worked in 1754. It is in a steep hill on the border of New River, a fall upon which, near the mine, affords power for raising the water required in dressing the ores, and also for producing the blast for the furnace. Several shafts have been sunk, one of which extending down to the adit—a depth of 225 feet—is used as a shot tower. The ores are galena, with more or less carbonates intermixed. The product for 1855 is stated to have been 500 tons of lead. The transportation of lead, in pigs, bars, and shot, from the south-west part of Virginia toward the east, by the

Virginia and Tennessee railroad, for the years named, has been as follows:—

	1856. lbs.	1857. lbs.	1858. lbs.	1859. lbs.
Pig Lead	409,649	514,878	163,405	854,695
Bar Lead		234,037	52,230	22,580
Shot	364,660	120,142	104,623	254,970
Total	774,309	869,057	320,258	1,132,245

In the other direction the transportation of the same articles was comparatively unimportant.

South of Virginia the only lead mine of importance is the Washington mine, Davidson county, N. C. This was opened in 1836, in the silicious and talcose slates of the gold region, and was worked for the carbonate of lead, which was found in a dull, heavy ore of earthy appearance, with which were intermixed glassy crystals of the same mineral. Some galena and phosphate of lead were also met with. After a time native silver was detected, and the lead that had been obtained was found to be rich in silver. Till 1844 the mine continued to produce ores containing much silver, and afforded the first deposits of this metal in the mint from domestic mines. The character of the ores changed, however, below the depth of 125 feet, the silver almost disappearing. The actual product of the mine is not known. That of 1844 is said to have been $24,209 in value of silver, and $7,253 of gold, obtained from 160,000 lbs. of lead—an average of 240 oz. of auriferous silver to 2,000 lbs. of metal. In 1851 the production was 56,896 lbs. of lead and 7,942.16 oz. of auriferous silver—equal to 279 oz. to the ton of metal. Zinc blende and galena became at last the prevailing ores, the silver varying from 2.5 to 195 oz. to the ton; and the workings were extended upon two parallel veins which lay near each other in the slates. In 1852 mining operations were abandoned as unprofitable, but were soon after renewed, and are still continued.

The great lead mines of the United States are the upper mines, in a district near the Mississippi, in Iowa, the south-west part of Wisconsin, and the north-west part of Illinois; and the lower mines, in Missouri. The existence of lead ores in the upper district was made known by Le Sueur, who discovered them in his voyage up the Mississippi in 1700 and 1701. They attracted no further attention, however, till a French miner, Julien Dubuque, commenced to work them in 1788; and in this employment he continued, on the spot where now stands the city in Iowa bearing his name, until his death in 1809. When the United States acquired possession of the country in 1807, the mineral lands were reserved from the sales, and leases of mining rights were authorized. These were not, however, issued until 1822, and little mining was done before 1826. From that time the production of lead rapidly increased; and the government for a time received the regular rates for the leases. But after 1834 the miners and smelters refused to pay them any longer, on account of so many sales having been made and patents granted of mineral lands in Wisconsin. In 1839 the United States government authorized a geological survey of the lead region, in order to designate precisely the mineral tracts, and this was accomplished the same year by Dr. D. D. Owen, with the aid of 139 assistants. In 1844 it was decided to abandon the leasing system, and throw all the lands into the market. The lead region, according to the report of Dr. Owen, extends over about 62 townships in Wisconsin, 10 in the north-west corner of Illinois, and 8 in Iowa—a territory altogether of about 2,880 square miles. Its western limit is about 12 miles from the Mississippi river; to the north it extends nearly to Wisconsin river; south to Apple river, in Illinois; and east to the east branch of the Pekatonica. From east to west it is 87 miles across, and from north to south 54 miles. Much of the region is a rolling prairie, with a few isolated hills, called mounds, scattered upon its surface, the highest of them rising scarcely more than 200 feet above the general level. The prevailing limestone formations give fertility to the soil, and the country is well watered by numerous small streams, which flow in valleys excavated from 100 to 150 feet below the higher levels. The limestone, of gray and yellowish gray colors, lies in nearly horizontal strata, and the portion which contains the lead veins hardly exceeds 50 feet in thickness. Beneath it is a sandstone of the age of the Potsdam sandstone, and above it are strata of limestone recognized as belonging to the Trenton limestone, so that it proves to be a formation interposed between these, quite western in character, as it is not met with east of Wisconsin. The veins occupy straight vertical fissures, and several near together sometimes extend nearly a mile in an east and west direction. They never reach downward into the sandstone,

but are lost in the lower strata of the limestone, and where the upper strata of the formation appear, these cover over the veins, and are consequently known as the cap-rock. In the fissures or crevices the galena is found, sometimes in loose sheets and lumps embedded in clay and earthy oxide of iron, and sometimes attached to one or both walls. It is rarely so much as a foot thick. No other ores are found with it, except some zinc blende and calamine, and occasionally pyritous iron and copper. The lead contains but a trace of silver. The fissures, as they are followed beneath the surface, sometimes expand in width till they form what is called an "opening;" and the hollow space may go on enlarging till it becomes a cave of several hundred feet in length and 30 or 40 in width. Their dimensions are, however, usually within 40 or 50 feet in length, 4 to 8 in width, and as many in height. The walls of the openings often afford a thick incrustation of galena, besides more or less loose mineral in the clay, among the fragments of rock, with all of which the caves are partially filled. Flat sheets of ore often extend from the vertical fissures between the horizontal limestone strata; these are more apt to contain blende, and pyrites, and calcareous spar than the ore of the vertical crevices. Besides these modes of occurrence, galena is found in loose lumps in the clayey loam of the prairies. This is called float mineral, and is regarded as an evidence of productive fissures in the vicinity.

The galena occurs under a variety of singular forms in the crevices. It lines curious cavities which extend up in the cap-rock, terminating above in a point, and which are known as chimneys. Upon the roofs of the openings it is found in large bunches of cubical crystals, and the same are obtained lying in the clays of the same openings. A flat sheet of the ore was worked in Iowa that was more than 20 feet across and from 2 to 3 feet thick, each side of which turned down in a vertical sheet, gradually diminishing in thickness. It yielded 1,200,000 lbs. of rich galena, and more still remained behind in sight. The crevices near Dubuque are the most regular and productive of any in the district. One called the Langworthy, on a length of about three-fourths of a mile, has produced 10,000,000 lbs. of ore. On the main fissure there were usually three ranges of crevices one above another, widening out to 15 or 20 feet.

The smelters of this region form a distinct class from the miners, of whom the former buy the ores as these are raised, and convert them into metal in the little smelting establishments scattered through the country. The lead has been principally sent down the Mississippi river to Saint Louis and New Orleans; but a portion has always been consumed in the country, and some has been wagoned across to Milwaukee before the construction of railroads, which since 1853 have afforded increased facilities for distributing in different directions the product of the mines. The only records of the amount of lead obtained are those of the shipments down the river. The following table presents the number of pigs shipped from the earlier workings to 1857; the figures for 1841 to 1850, inclusive, being furnished to Dr. Owen's Report of 1852 by Mr. James Carter, of Galena. The pigs weigh about 70 lbs. each.

SHIPMENTS OF LEAD FROM THE UPPER MISSISSIPPI.

Years.	Pigs.	Years.	Pigs.
1821 to 1823...	4,790	1842.....	447,859
1824.....	2,503	1843.....	561,321
1825.....	9,490	1844.....	624,601
1826.....	13,700	1845.....	778,460
1827.....	74,130	1846.....	730,714
1828.....	158,655	1847.....	771,679
1829.....	190,620	1848.....	680,245
1830.....	119,060	1849.....	628,934
1831.....	91,170	1850.....	569,521
1832.....	61,164	1851.....	474,115
1833.....	113,440	1852.....	408,628
1834.....	113,648	1853.....	425,814
1835.....	158,330	1854.....	423,617
1836.....	191,750	1855.....	430,365
1837.....	219,360	1856.....	435,654
1838.....	200,465	1857.....	485,475
1839.....	357,785	1858.....	
1840.....	317,845	1859.....	
1841.....	452,814		

The lead region of Missouri was first brought into public notice by the explorations of the French adventurer, Renault, who was sent out from Paris in 1720, with a party of miners, to search for precious metals in the territory of Louisiana, under a patent granted by the French government to the famous company of John Law. Their investigations were carried on in the region lying near the Mississippi and south of the Missouri river; and here, though they failed to find the precious metals they were in search of, they discovered and opened many mines of lead ore. A large mining tract in the northern part of Madison county is still called by the name of their mineralogist, La Motte. Their opera-

tions, however, were altogether superficial, and the lead they obtained was wholly by the rude and wasteful process of smelting the ores upon open log-heaps—a practice which even of late years is followed to some extent. Up to Renault's return to France, in 1742, little progress had been made in the development of this mining district. The next step was made by one Moses Austin, of Virginia, who obtained from the Spanish government a grant of land near Potosi, and commenced in 1798 regular mining operations by sinking a shaft. He also started a reverberatory furnace and built a shot tower. Schoolcraft states in his "View of the Lead Mines of Missouri," that there were in 1819 forty-five mines in operation, giving employment to 1,100 persons. Mine à Burton and the Potosi diggings had produced from 1798 to 1816 an annual average amount exceeding 500,000 pounds; and in 1811 the production of Mine Shibboleth was 3,125,000 pounds of lead from 5,000,000 pounds of ore. At a later period, from 1834 to 1837, the several mines of the La Motte tract produced, it is estimated, 1,035,820 pounds of lead per annum. From 1840 to 1854 the total yield of all the mines is stated by Dr. Litton in the state geological report to amount to over 3,833,121 pounds annually. At the close of this period it had, however, greatly fallen off, there being at that time scarcely 200 persons engaged in mining, besides those employed at the three mines known as Perry's, Vallé's, and Skewers'. The principal mines have been in Washington, St. Francis, and other neighboring counties. The ores are found in strata of magnesian limestone of an older date than the galena limestone of Wisconsin, and supposed to lie, with the sandstones with which they alternate, on the same geological horizon as the calciferous sand rock, which is found in the eastern states overlying the Potsdam sandstone. Some of the mines are at the contact of the horizontal limestone with granite rocks, but the ores in this position are only in superficial deposits or in layers included in the limestone. In their general features the veins do not differ greatly from those of the northern mines. Some of them, however, contain a larger proportion of other ores besides galena, as well as a greater variety of them. Carbonate of lead, called by the Miners dry bone and white mineral, is more abundant, and also blende, called by them black jack, and the silicate of zinc. Iron and copper pyrites are often seen, and at Mine la Motte are found the black oxides of cobalt and manganese associated with the carbonates of lead and copper. Nearly all the mining operations have been mere superficial excavations in the clay, which were soon exhausted of the loose ore and abandoned. But to this there are some remarkable exceptions of deeper and more permanent mines than are known in the northern lead regions. Such are Vallé's and Perry's mines, both situated on the same group of veins, which form a network of fissures and openings running in every direction and spreading over an area of about 1,500 feet in length by 500 in breadth, the extension of which is from north-west to south-east. These mines have been steadily worked since 1824, and 22 shafts have been sunk upon the fissures, six of which are over 110 feet deep, one is 170 feet deep, and only two are less than 50 feet. For the first 10 to 30 feet they pass through gravel and clay, below this through a silicious magnesian limestone of light color, and then enter a very close-grained variety of the same, called by the miners the cast steel rock. A succession of openings are encountered, which are distributed with considerable regularity upon three different levels. Those of the middle series have been the most productive. Sometimes chimneys connect them with the caves of the tier above or below. The portion of these mines on the Vallé tract produced, according to the state report, from 1824 to 1834 about 10,000,000 pounds of lead, and in the succeeding 20 years about as much more; and Perry's mine from 1839 to 1854 has produced about 18,000,000 pounds.

No accurate estimates have been preserved of the total production of the Missouri mines. This has always fallen far short of the yield of the northern mines. From 1832 to 1843 it is reported as running from 2,500 to 3,700 tons per annum, while that of the northern mines in the same time was from 5,500 to 14,000 tons, and in 1845 it even exceeded 24,000 tons. In 1852 Mr. J. D. Whitney estimated that the production in Missouri had fallen to 1,500 tons, or less; and from that period it has probably not advanced. As this decrease in the supply has been going on while the price of lead has risen to nearly three times what it was in 1842, the cause is probably

owing to the mines themselves being in great part exhausted. The only sufficient sources known from which the increasing supplies required from year to year can be furnished, are the mines of Great Britain and Spain, though should the argentiferous lead mines of Mexico ever be worked for the lead as well as the silver they contain, they might furnish large quantities of the former metal. As the production of the United States has fallen off, that of Great Britain has increased from 64,000 tons in 1850 to 73,129 tons in 1856, and 96,266 tons in 1857, thus considerably exceeding one-half of the whole production of the globe in this metal, which in 1854 was rated at about 133,000 tons. At that time the production of Spain was rated at 30,000 tons, and of the United States at 15,000 tons. The following table, from *Hunt's Merchants' Magazine*, of July, 1859, presents several features of interest in the history of this business. The amount of domestic lead received at St. Louis and New Orleans is not, however, a true index of the production of the American mines, and the falling off of the figures in the second column for several years past, is properly accounted for to some extent by the new outlets opened from the northern mines eastward, and also by the largely increased consumption of the metal in the western states.

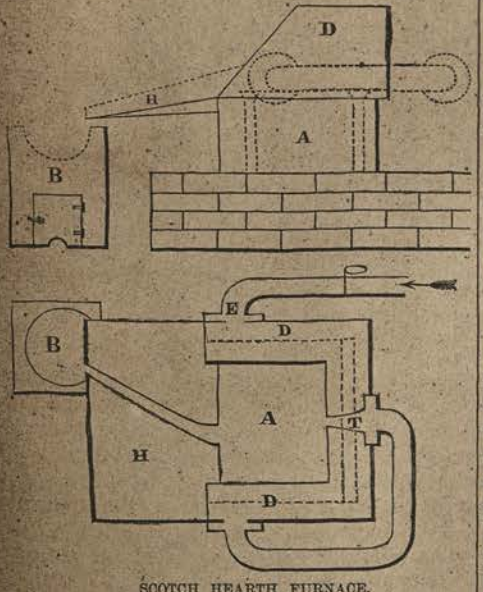
Years.	Pig lead from American mines received at St. Louis and New Orleans. lbs.	Pig, bar, and sheet lead imported. lbs.	Invoice value of yearly importations.	Average rate of duty per 100 lbs.	White and red lead imported lbs.	Invoice value of yearly importations.
1832	8,540,000	5,333,588	$124,311	$3.00	557,781	$30,791
1833	12,600,000	2,282,068	60,660	3.00	625,069	36,049
1834	14,140,000	4,997,293	168,811	2.77	1,024,663	57,572
1835	16,000,000	1,006,472	35,663	2.77	832,215	50,225
1836	18,000,000	919,087	35,283	2.55	908,105	62,237
1837	20,000,000	335,772	13,871	2.57	599,980	47,316
1838	20,860,000	165,844	6,573	2.34	522,681	38,683
1839	24,000,000	528,922	18,631	2.31	720,408	50,905
1840	27,000,000	519,343	18,111	2.08	643,418	41,043
1841	30,000,000	62,246	2,605	2.07	532,122	31,617
1842	33,110,000	4,689	155	3.00	479,738	28,747
1843	39,970,000	290	3	3.00	93,166	5,600
1844	44,730,000	..	..	3.00	..	..
1845	51,240,000	19,609	458	3.00	231,171	14,744
1846	54,950,000	214	6	3.00	215,434	15,685
1847	46,130,000	224,905	6,288	0.56	298,387	15,228
1848	42,420,000	2,684,700	85,387	0.64	318,781	19,703
1849	35,560,000	..	..	..	..	..
1850	40,313,910	36,997,751	1,182,597	0.64	853,463	43,756
1851	34,934,480	43,470,210	1,517,603	0.70	1,105,852	52,631
1852	28,593,180	37,544,588	1,283,331	0.70	842,521	43,365
1853	31,497,950	43,174,447	1,618,058	0.70	1,224,068	69,058
1854	21,472,990	47,714,140	2,095,039	0.90	1,865,893	102,812
1855	21,441,140	56,745,247	2,556,523	0.90	2,319,099	134,855
1856	15,347,880	55,294,256	2,528,014	0.91	3,548,409	174,125
1857	14,028,140	47,947,698	2,305,768	0.72	1,793,377	113,075
1858	21,210,420	41,230,019	1,972,243	0.72	1,785,851	109,426

For the year ending June 30, 1859, the imports of lead are given at 64,000,000 pounds, worth nearly $2,700,000. Of this about $57,000 worth were re-exported to foreign countries, besides American lead to the value of $30,000, and a small amount of manufactured lead.

LEAD SMELTING. The lead mines of the United States being scattered over wide territories, and their products being nowhere brought together in large quantities, the process of reducing the ores has been conducted in small establishments and by the most simple methods. The earlier operations were limited to smelting the ores in log furnaces. Upon a layer of logs placed in an inclosure of logs or stones piled up, split wood was set on end and covered with the ore, and over this small wood again. The pile was fired through an opening in front. The combustion of the small wood removed from the ore a portion of the sulphur, and the reduction was completed by the greater heat arising from the burning of the logs. The lead run down to the bottom and out in front into a basin, whence it was ladled into

the moulds. The loss of metal was of course very large; but a portion was recovered by treating the residue in what was called an ash furnace. The process is still resorted to in places where no furnaces are within reach. But wherever mines are opened that promise sufficient supplies of ore, furnaces are soon constructed in their vicinity. Those in use are of two sorts: the Scotch hearth and the reverberatory. Besides these, another small furnace is often built for melting over the slags. This is little else than a crucible built in brick-work, and arranged for the blast to enter by an aperture in the back, and for the metal to flow out by another opening in front.

The Scotch hearth is a small blast furnace, but resembles the open forge or bloomary fire for iron ores. It has long been in use in Europe, and is the most common furnace at our own mines. In this country it has been greatly improved by the introduction of hot blast; and in its most perfect form is represented in the accompanying figures; figure *a* being a vertical section from front to back, and figure *b* a horizontal section.



SCOTCH HEARTH FURNACE.

A is the reservoir of lead of the furnace, consisting of a box, open at top, about two feet square and one foot deep, formed of cast iron 2 inches thick. From its upper front edge a sloping hearth, H, is fixed so as to receive the melted lead that overflows, and conduct it by the groove into the basin, B. In this it is kept in a melted state by a little fire beneath, and, as convenient, the lead is ladled out and poured into moulds. D is a hollow shell of cast iron ¾ of an inch thick, its inner and outer sides inclosing a space of 4 inches width. Into this space the blast is introduced at E, and becoming heated, passes out at F, and thence through the curved pipe into a tuyere, T, cast in the air-chest 2 inches above the level of the lead reservoir. Before commencing operations this reservoir is to be filled with lead, and is thus kept so long as the furnace is in use; the process being conducted upon the surface of the melted metal. The furnace may be kept in continual operation by adding new charges of galena every ten or fifteen minutes, and working them down after they have become roasted at the surface. The fuel employed is dry pine wood split into small pieces, and billets of these are thrown in against the tuyere just before each new charge of ore, that already in the furnace being raked forward upon the hearth to make room for the fuel, and the blast being temporarily turned off. The old charge is then thrown, together with fresh ore, upon the wood, and the blast is let on, when the heat and flame immediately spread through the materials. The sulphur in the ore serves itself as fuel, accelerating the process by its combustion, and in a few minutes the whole charge is stirred up, spread out on the hearth, and the hard, unreduced fragments are broken in pieces by blows of the shovel. Slaked lime is sometimes added in small quantity when the partially reduced ore becomes too soft and pasty by excess of heat. Its effect is to lessen this tendency rather by mechanical than chemical action. If any flux is used, it is fluor spar, blacksmith's cinders, or bits of iron. The latter hasten the reduction by the affinity of the iron for the sulphur of the ore. The cast iron of the air-chest is protected from the action of the sulphur by the cooling influence of the air blown in; and this is also advantageous by its keeping the furnace from becoming so hot, that the galena would melt before losing its sulphur, and thus form combinations of exceedingly difficult reduction. A fan, run by steam or water power, is commonly employed for raising the blast; but as this gives little pressure, it is replaced to great advantage by blowing cylinders, with an air-

receiver for giving regularity to the current of air. With such an apparatus, the smelter can apply the blast with great advantage at times to help loosen up the charge and throw the flame through every part of it. The ores are prepared for smelting by separating from them all the stony and clayey particles, and as much as possible of the blende and other impurities that may accompany them. This may require a succession of mechanical processes, in which the ores are crushed to fine fragments and dressed by jigging and screening under water. Not only is the labor and cost of smelting reduced by the purity of the ore, and especially its freedom from blende and pyrites, but the quality also of the metal is thereby improved. Lead that contains iron is not adapted for the manufacture of white-lead. The American metal being generally free from this brings a higher price than Spanish or English lead. With pure ore a cord of wood may be made to produce four tons of lead; and each furnace 7,500 lbs. every 24 hours; a smelter and his assistant managing the operation for 12 hours. At Rossie large quantities of lead have thus been smelted at a daily cost for labor of $5, and for fuel of $1.50, making $1.75 per ton. In Wisconsin, before the use of the hot blast, each furnace-shift was continued from 8 to 10 hours, until 30 pigs of lead were produced of 2,100 lbs. weight, at an expense of about $4 for labor, and $1.50 for fuel.

The other form of furnace—the reverberatory—resembles others of this class employed in smelting copper ores. The sole, or hearth, upon which the ores are spread, is about 8 feet in length by 6 in breadth, and is made to incline rapidly toward an aperture on one side, or at the end under the chimney, and out of which the lead is allowed at the end of each smelting to flow into a receiver outside. The charge is supplied either through a hopper in the arched roof, or through the holes in the sides, which also serve for admitting the pokers used by the workmen to stir up the charge. Unless the galena has been previously calcined or roasted—a process necessary for poor ores only—this is the first thing to be attended to in all the smelting operations. In the large charge of 30 cwt. of ore this usually takes the first two hours of the process, and is effected in great part by the heat remaining in the furnace from the preceding operation, the doors at the sides being kept open at the same time to allow free access of air. The oxidation of the sulphur is expedited by almost constant stirring of the charge, which brings fresh portions to the surface, causing an evolution of white fumes. As these begin to diminish, the fire is started on the grate, and the heat is raised till the charge softens and the pieces of ore adhere to the rake. The doors are then closed, and the fire is urged for a quarter of an hour, when the smelter opens the door to see if the metal separates and flows down the inclined hearth. If the separation does not go on well, it is hastened by opening one of the doors, partially cooling the furnace, and stirring the charge. The fire is then again urged. If the slags which form seem to require it, he treats them with a few shovelfuls of lime and fine coal; and when, after having flowed down into the lower portion of the hearth, they are brought into a doughy consistency, the smelter pushes the slag to the opposite upper edge of the hearth, from which it is taken out through a door on that side by his assistant, while he lets off the lead into the receiver.

The separation by this method is not so perfect as by the Scotch hearth, and the expense of fuel is greater; but the reverberatory is worked without the necessity of steam or water power, which is required to raise the blast for the other process. The slags of the reverberatory contain so much lead that they are always remelted in the slag furnace. Those of the Scotch hearth, when pure ores are employed, are sufficiently clear of metal without further reduction. In Europe other sorts of furnaces are in use, which are adapted particularly for ores of poorer quality than are ever smelted in the United States.

In the Hartz mountains, at Clausthal, argentiferous silver ores containing much silica are worked in close cupola furnaces, into which only enough air is admitted to consume the fuel. The object is not to roast out the sulphur, but to cause this to combine with the granulated cast iron or with the quick-lime, either of which is mixed with the ores to flux them and form a fusible compound with the sulphur, through which the metallic lead can easily find its way to the bottom. The production of a silicate of lead is thus avoided, which is a difficult compound to reduce, and is always formed when much silica is present. This process

will probably be applied to some of the silicious ores of the United States, and may be particularly suited to the Washoe ores of California.

By all the methods of reducing lead a great loss is incurred by the volatilization of a portion of the lead in white fumes, called lead ashes. These are carried up through the chimney of the furnace and fall upon the ground in the neighborhood, poisoning the vegetation, and the water by the carbonate of lead, which results from the fumes. Trees even are killed, and the dogs die off, and also the cattle. In Scotland the lead has been detected in chemical examinations of the bodies of animals thus killed, and it was particularly noticeable in the spleen. For the injury thus occasioned at the furnaces of the United States no remedy has been applied, but at many of the great establishments in Europe, where the loss of lead and the damage to the neighborhood is much more serious, attempts have been made to arrest the fumes, by causing them to pass through long flues in the chimney stacks, in which the particles on cooling would settle down; and their cooling has been hastened by showers of water falling among the vapors. Flues have been extended great distances beyond the works, and have been found much more efficient than any form of condensation by sudden cooling. Some of the works constructed for this purpose are very remarkable for their great extent and the saving they have effected, and similar ones may perhaps be found well worthy of construction at some of the smelting establishments in the United States. At the works of Mr. Beaumont, in Northumberland, England, horizontal or slightly inclined galleries have been completed in stonework, 8 feet high and 6 feet wide, for an extent of 8,789 yards (nearly five miles). This is from one mill alone. The same proprietor has connected with other mills in the same district and in Durham four miles of galleries for the same purpose. The writer who gives the account of these in the recent edition of Ure's Dictionary, by Robert Hunt, remarks: "The value of the lead thus saved from being totally dissipated and dispersed, and obtained from what in common parlance might be called chimney sweepings, considerably exceeds £10,000 sterling annually, and forms a striking illustration of the importance of economizing our waste products." Not only is lead lost in the fumes, but in the working of argentiferous lead ores, a portion of the silver too is carried off and deposited with them. The fumes collected at the works of the Duke of Buccleuch yield one-third their weight of lead, and five ounces of silver to the ton. The loss of silver is of little importance in this country, where this metal is not obtained at the present time, unless it be at the Washington mine, in North Carolina, and at the Washoe mines, in California; and consequently methods of separating it from the lead possess little more than scientific interest. In the smelting of argentiferous lead ores, the silver goes with the lead, being completely dissolved and diffused throughout its substance. The usual way of separating it is founded on the principle of the lead being a metal easily oxidized and converted into the substance called litharge, in which condition it lets go the silver, which has no affinity either for the new compound of oxygen and lead, or for the oxygen alone. The change is effected by melting the lead in the shallow basins called cupels, formed of a porous earthy material, as the pulverized ashes of burned bones, kneaded with water, and mixed in a framework of iron. When dried, these are set in a reverberatory furnace, and the pigs of lead are melted upon their surface. After being thoroughly heated, a current of air is made to draw through an opening in the side of the furnace directly upon the face of the melted metal. This oxidizes the lead, and the yellow litharge with more or less red oxide, called minium, collects in a thin film upon its surface, and floats off to the edge, sinking into and incrusting the cupel and falling over its side into a receptacle placed to receive it. This process goes on, the lead gradually disappearing as the oxygen combines with it, till with the removal of the last films of oxide the melted silver suddenly presents its brilliant, perfectly unsullied face. The oxide of lead may be collected and sold for the purposes of litharge, as for a pigment, for use in the manufacture of glass, etc.; or it may be mixed with fine coal and converted back into lead, the carbon of the coal effecting this change by the greater affinity it has at a high heat for the oxygen, than the lead has to retain it. By this process, known as cupellation, lead is hardly worth treating for silver, unless it contain about 10 ounces to the ton of the precious metal; and it was therefore an important object to devise a

method of saving with economy the silver lost in the large quantities of the poorer argentiferous leads. Such a method was accidentally discovered in 1829 by Mr. Pattinson, of Newcastle, and is now extensively in use in Europe for the poorer silver-leads, cupellation being preferred for the richer. He observed that when the lead containing silver forms crystals, as it is stirred while in a melted state, the crystals contain little or none of the silver, and may be removed, thus concentrating the silver in the portions left behind. This crystallizing process is applied in the large way as follows: Cast iron pots are set in brick-work side by side, capable of holding each one 4 or 5 tons of lead. The middle one is first charged, and when the lead is melted and stirred, the fire is removed under the next pot to the right; and into this crystals of lead as they form are ladled by means of a sort of cullender, which lets the fluid lead fall back. This instrument is kept hotter than the lead by frequently dipping it in a pot of lead over a separate fire. When four-fifths of the lead have been transferred to the pot to the right, the remainder, which contains all the silver, is removed to the next pot to the left, and the middle pot is then charged with fresh lead, which is treated in the same manner. The process is repeated with each pot, as it becomes full, four-fifths of its contents going to the next pot to the right, and one-fifth to the next to the left, and thus the lead is finally discharged into moulds at one end, and the argentiferous alloy, concentrated to the richness of 300 ounces of silver to the ton, is run into bars about 2 inches square. From these the silver is obtained by cupellation. At one establishment in England, that of Messrs. Walker, Parker & Co., the weekly product of silver is from 8,000 to 10,000 ounces. Whenever the lead mines of the eastern states are made to yield regular returns of lead, the separation of its silver is likely to be carried on in independent establishments, supplied like the copper-smelting works with material from various sources. Works having these objects in view were established in the fall of 1860, at Brooklyn, New York, by Messrs. Bloodgood & Ambler, and will commence operations with the smelting of the Washoe silver-lead ores from California, of which over sixty tons have been delivered at the works for reduction. Their successful treatment will no doubt be followed by the shipment of other ores of the different metals from various sources; and it is to be hoped that it will hereafter be found more advantageous to send ores to New York to be reduced, than to the smelting establishments on the other side of the Atlantic.

Useful Applications of Lead.—A considerable part of the lead product of the world is converted into the carbonate, known as white lead, and used as a paint. The principal articles of metallic lead are sheet lead, lead pipe, and shot. Sheet lead is manufactured in two ways. The melted lead is upset from a trough suspended over a perfectly level table, covered with fine sand, and furnished with a raised margin; and when the metal has spread over this, a couple of workmen, one on each side, carry along a bar supported upon the margin, pushing forward the excess of lead above that necessary for the required thickness, till it falls over the end of the table. By the other method, called milling, the lead is cast in a plate, 6 or 7 feet square, and 6 inches thick, and this being taken up by a crane, is placed upon a line of wooden rollers, which form a flooring for the length it may be of 70 or 80 feet and a width of 8 feet. Across the middle of this line are set the two heavy iron rolls by which the lead plate is compressed, as it is passed between them. The top of the lower roll is on a level with the top of the wooden rollers, and the upper roll is so arranged that it can be set nearer to or further from the lower one, as the thickness of the plate requires.

Lead pipe was formerly made by turning up sheet lead and soldering the edges; and is still prepared in this way for the large sizes, as those over six inches diameter. After this a method was contrived of casting the lead in a hollow cylindrical plug, its inner diameter of the bore required, and then drawing this down through slightly conical dies of decreasing diameter, a mandril or steel rod being inserted to retain the uniform diameter of the bore. Pipes made in this way were limited to 15 to 18 feet in length, and the metal was full of flaws. Many attempts have been made to cast long lengths of lead pipe, all of which have proved unsuccessful. In 1820 Thomas Burr, of England, first applied the hydraulic press to forcing lead, when beginning to solidify in cooling, through an annular space between a hollow ring and a solid core secured in its centre. He thus produced pipes of considerable

length. The method of forcing the liquid metal through dies to form pipes was, however, first patented in 1797 by Bramah, who used a pump for this purpose. The process was introduced into this country in 1840–41 by Messrs. Tatham & Brothers, now of New York, who invented and patented an important improvement in the method of securing the die and core. In this operation the melted lead is made to flow from the furnace into a cylindrical cavity in a block of cast iron, which may be of 1800 lbs. weight, and from this, when cooled to the proper temperature, it is forced out through the die by a closely-fitting piston. By one process the piston, starting from the bottom of the cylindrical cavity, moves upward, carrying with it the slender core or rod which determines the diameter of the bore of the pipe, and pushes the melted lead before it through the die fixed in the top of the cast iron block. The pipe as it is formed passes out from the top of the machine, and is coiled around a receiving drum. By the machine contrived by Mr. Cornell of New York, the great iron block containing the lead rises by the pressure of the hydraulic machine, and the piston which is fixed above it enters the cavity. The piston in this case is hollow and the die is set in its lower end. The core is secured in the bottom of the block, and is carried upward as this rises. The pressure applied in this operation amounts to 200 to 300 tons. Dies are used of a great variety of sizes, according to the kind of pipe required. Lead wire is made in this way with a die of very small size without a core. It is used for securing vines and attaching tags to fruit trees and shrubs. The principal works in the United States engaged in the manufacture of sheet lead and lead pipe are in New York, Boston, Philadelphia, Chicago, Cincinnati, and Saint Louis.

Lead pipe is in general use as the most convenient conduit for water for domestic purposes. It is readily bent to any angle, and is made to adapt itself to any position. When water freezes within and bursts it, the damage is easily repaired; joints are also made with little trouble. The lead is not liable to become rusty like iron, and is cheaper than tin or copper. These qualities give to it a preference over other kinds of pipe, notwithstanding the very serious objection that the lead is often acted upon by the water, and produces poisonous salts of a very dangerous character. Some waters more than others have a tendency to promote the oxidation of the lead. This is particularly likely to occur with nearly all waters in pipes which are alternately exposed to the action of air and water, as when the water being drawn out, the air enters and takes its place. The oxide of lead is converted by carbonic acid gas, which is present in almost all water, into a carbonate of lead which is soluble to some extent in an excess of the gas, and is carried along, bearing no indication of its presence, while the lead pipe continues to be corroded until it may be in places eaten nearly through. The water used for drinking and for culinary purposes is thus continually introducing an insidious poison into the system, the effect of which is at last experienced in the disease known as the painters' colic, often followed by paralysis. As this occurs without a suspicion being awakened of the real source of the disease, and is produced by quantities so small as from $\frac{1}{10}$ to $\frac{1}{20}$ of a grain in the gallon, the use of lead pipe is properly regarded by scientific men as always unsafe; and some substitute for this metal in pipes and in sheets used for lining water cisterns, is highly desirable. It has been proposed to coat the pipe with some insoluble lining; but such an application necessarily increases its cost, it may perhaps be removed by hot water flowing through the pipe, and the purchaser may have no confidence in the coating being faithfully applied, or as certain to be efficient during long-continued use. Block tin is perfectly safe, but it is expensive, and is moreover likely to be alloyed with the cheaper metal lead, which in this condition is thought to be equally dangerous as when used alone. As no popular substitute for lead is provided, it is a reasonable precaution for those employing it to be always watchful and on their guard against its evil effects—using as little of it as necessary, causing the water to be occasionally tested, and, whenever opportunity offers, cutting open and examining pieces of the pipe to see whether its internal surface is corroded, and every morning before using the water that has stood in the pipes, to cause this to flow away together with enough more to thoroughly wash out the pipes and remove any salts of lead that may have formed in them during the night.

Large quantities of lead are consumed in the United States in the manufacture of shot and bullets; and one ingenious method of producing shot is an American invention.

The quality of the lead employed for this purpose is of little importance. The harder and inferior sorts, which would not answer for the white lead manufacture, are economically diverted to this object. If too brittle, from the iron and antimony combined with the lead, the metal is made to assume the right quality by mixing with it a small proportion of arsenic, which, for most kinds of lead, may amount to one per cent. To introduce this into the lead a large pot of the metal is melted, and powdered charcoal or ashes is laid around its edge. The arsenical compound, either of white arsenic or of orpiment (the sulphuret of arsenic), is then stirred into the centre of the mass, and a cover is tightly luted over the pot. In the course of a few hours, the mixture being kept hot, the combination of the lead with the arsenic is completed, and a portion of litharge floats upon the surface. This is formed from the oxygen of the white arsenic uniting with some of the lead, and it retains a portion of the arsenic. The alloy is now tried by letting a small quantity of it fall from a moderate height through a strainer into water. From the appearance of the globules the quality of the mixture is judged of. If they are lens-shaped, too much arsenic has been used; but if they are flattened on the side, or hollowed in the middle, or drag with a tail behind them, the proportion of arsenic is too small. When a proper mixture is obtained it is run into bars, and these are taken to the top of a tower, from 100 to 200 feet high, where the lead is melted and poured through cullenders, which are kept hot by being placed in a sort of chafing-dish containing burning charcoal. The lead is thus divided into drops that fall to the bottom, and are received in a vessel of water. Each cullender has holes all of the same size, which is considerably less than that of the shot produced by them. This is owing to the drop of melted lead first assuming an elongated form, which is concentrated into the globular by the air impinging equally upon all sides in the course of its descent. When it reaches the water, it is important that it should have cooled throughout, so that no solid crust be suddenly formed over a fluid interior; and hence, for large shot it is evident the height of the fall must be greater than is required for small shot. The temperature of the lead also, when it is dropped, must vary according to the size of the shot; for the largest size being so low that a straw is hardly browned when thrust into it. A portion of the lead becomes oxidized and is caught in the cullender, the bottom of which it coats, and serves a useful purpose by checking the too rapid flow of the melted lead through the holes. The holes vary in size, from $\frac{1}{50}$ of an inch for shot larger than No. 1, to $\frac{1}{300}$ of an inch for No. 9. The shot being taken out of the water and dried upon the surface of a long steam chest, are transferred to an iron cask suspended upon an axis passing through its ends, and a little plumbago being introduced with them, the cask is made to revolve until the shot are thoroughly cleaned and polished. The next operation is to separate the imperfect ones from the good. This is done by rolling them all together down a succession of inclined platforms, separated by a narrow space between each. The good shot clear these spaces and are caught below, while the bad ones fall through upon the floor. The good are then introduced into the sifters for assorting them according to their sizes. Several sieves are arranged like drawers in a case; the coarsest above, and finer ones succeeding below. The upper tier of sieves being charged, the case is set rocking, and the shot are soon assorted, and are then ready for packing in bags. Bullets and buck-shot are moulded by hand from a large pot of the metal into moulds with many receptacles.

The American process of shot-making was invented in 1848 by David Smith, of the firm of T. O. Leroy & Co., of New York, by whom it is exclusively used. Its object is to dispense with the use of the costly high towers, by substituting for them a lower fall against an ascending current of air. This current is produced by a fan-blower operating at the base of an upright hollow shaft into which the shot are dropped from a moderate height. The power required to run the fan is not much more than that ordinarily expended in raising the lead to the top of the high towers; and it is found that the lead, in consequence of its being more rapidly and equally cooled in the short descent against the current of air, may be used at a higher temperature than is practicable with that dropped from high towers; and thus it may not only be poured more rapidly, but it has not the tendency to burst in falling and form imperfect shot, as is the case with that dropped from high towers, to guard against which the lead is kept at a low temperature.

There are in New York city, besides this operation, which is carried on by Messrs. Leroy, in Water street, three shot towers, and a fourth is nearly completed on Staten Island. The ordinary capacity of these is from 3000 to 4000 tons of shot per annum. The annual shot production of St. Louis is about the same as that of New York, though there is now only one shot tower in use. There were formerly seven more on the river bluffs below the city, but these have hardly been used since 1847. In Baltimore is a tower the height of which, including ten feet constructed below the surface of the ground, is 256 feet, which exceeds by one foot the height of the famous tower in Vienna, described by Dr. Ure as the highest structure of the kind in the world, being 249 feet above the surface of the ground. Its production is stated to be about 400 tons per annum. In Philadelphia there is one tower which makes about 300 tons annually; in Wythe county, Virginia, is one formed in one of the shafts of the mine, making about 200 tons; and on the Wisconsin river, at Helena, is a small tower probably making about as much more. The actual production of the country in shot and bullets is supposed to be about 7000 tons, and to have made but little advance for many years past.

White Lead.—Before the introduction of the oxide of zinc as a paint, one of the most important uses of lead was its conversion into the carbonate or white lead. The manufacture was originally carried on almost exclusively in Holland; and it was not until near the close of the last century that it was introduced into England. In the United States it was unknown until after the late war, and being first undertaken in Philadelphia, it was afterward extended to New York and Brooklyn, and in the latter city has prospered more than in any other part of the country. Various attempts have been made to introduce new methods of manufacture, but the old Dutch process has continued in general use; the modifications of it which have raised the manufacture in this country to a higher state of perfection than in any other part of the world being merely improvements in the details, by which ingenious machinery has been made to diminish the labor expended in the process.

White lead is a combination of oxide of lead with carbonic acid, and is obtained in the form of a soft, very white, and heavy powder. It mixes readily with oil, giving to it a drying property, spreads well under the brush, and perfectly covers the surfaces to which it is applied. It is not only employed alone as the best sort of white paint, but is the general material or body of a great number of paints, the colors of which are produced by mixing suitable coloring matters with the white lead. Besides its use as a paint it is also in demand to a considerable extent as an ingredient in the so-called vulcanized india-rubber. To prepare it, the purest pig lead, such as the refined foreign lead and the metal from the upper mines of the Mississippi, is almost exclusively used. This was by the old methods made in thin sheets, and these into small rolls, to be subjected to the chemical treatment. But according to the American method devised by Mr. Augustus Graham of Brooklyn, and now generally adopted, the lead is cast into circular gratings or "buckles," which closely resemble in form the large old-fashioned shoe-buckles, from which they receive their name. They are six or eight inches in diameter, and the lead hardly exceeds one sixth of an inch in thickness. Ingenious methods of casting them are in use in the American factories, by which the lead is run upon moulds directly from the furnace, and the buckles are separated from each other and delivered without handling, into the vessels for receiving them. They are then packed in earthen pots shaped like flower-pots, each of which is provided with a ledge or three projecting points in the inside, intended to keep the pieces above the bottom, in which is placed some strong vinegar or acetic acid. It is recommended that on one side the pot should be partially open above the ledge, and if made full all round, it is well to knock out a piece in order to admit a freer circulation of vapors through the lead. In large establishments an immense supply of these pots is kept on hand, the number at one of the Brooklyn works being reckoned at not less than 150,000. They continue constantly in use till accidentally broken below the ledge. Being packed with the buckles and the acid, they are set close together in rows upon a bed of spent tan, a foot to two feet thick, and thin sheets of lead are laid among and over the pots in several thicknesses, but always so as to leave open spaces among them. An area is thus covered, it may be twenty feet square or of less dimensions, and is enclosed by board

partitions, which, upon suitable framework, can be carried up twenty-five feet high if required. When the pots and the interstices among them are well packed with lead, a flooring of boards is laid over them, and upon this is spread another layer of tan; and in the same manner eight or ten courses are built up, containing in all, it may be, 12,000 pots and 50 or 60 tons of lead, all of which are buried beneath an upper layer of tan. As the process of conversion requires from eight to twelve weeks, the large factories have a succession of these stacks which are charged one after another, so that when the process is completed in one, and the pots and lead have been removed and the chamber is recharged, another is ready for the same operation.

The conversion of metallic lead into carbonate is induced by the fermenting action, which commences in the tan soon after the pile is completed. The heat thus generated evaporates the vinegar, and the vapors of water and acetic acid rising among the lead oxidize its surface and convert it externally into a subacetate of lead; at the same time carbonic acid evolved from the tan circulates among the lead and transforms the acetate into carbonate of the oxide, setting the acetic acid free to renew its office upon fresh surfaces of lead. When the tan ceases to ferment the process is at an end, and the stack may then be taken to pieces. The lead is found in its original forms, but of increased bulk and weight, and more or less completely converted into the white carbonate. The thoroughness of the operation depends upon a variety of circumstances; even the weather and season of the year having an influence upon it. The pieces not entirely converted have a core of metallic or "blue" lead beneath the white carbonate crust. The separation is made by beating off the white portion, and this being done upon perforated copper shelves set in large wooden tanks and covered with water, the escape of the fine metallic dust is entirely prevented and its noxious effect upon the health of the workmen is avoided. In Europe, rolling machines closely covered are applied to the same purpose, but less effectually. The white lead thus collected is next ground with water between millstones to a thin paste, and by repeated grindings and washings this is reduced to an impalpable consistency. The water is next to be removed, and, according to the European plan, the creamy mixture is next turned into earthen pots, and these are exposed upon shelves to a temperature not exceeding 300° until perfectly dry. Instead of this laborious method, the plan is adopted in the American works of employing shallow pans of sheet copper, provided with a false bottom, beneath which steam from the exhaust-pipe of the engine is admitted to promote evaporation. These pans or "drying kilns" are sometimes 100 feet long and 6 feet broad, and several are set in the building one above another. The liquid lead paste is pumped up into large tanks, and the heavier portion settling down, is drawn off into the pans, while the thinner liquid from the surface is returned to be mixed with fresh portions of white lead. Beside pans, tile tables heated by flues in the masonry of which they are built, are also employed. From four to six days are required for thoroughly drying the white lead. This is the finishing process, after which the lead is ready for packing in small casks for the market.

The manufacture of white lead, which was formerly an unhealthy and even dangerous occupation, has been so much improved by the expedients for keeping the material wet and thus preventing the rising of the fine dust, that the peculiar lead disease now rarely attacks the workmen. The business is conducted altogether upon a large scale, and though diminishing in importance, still supports a number of extensive factories in different parts of the country. Some of these have arrangements for converting-stacks that extend under cover 200 feet in length, and their facilities for grinding and drying are proportionally extensive. These and the time required for fully completing the process and getting the white lead ready for market—which is from three to four months—involve the use of large capital and tend to keep the business in few hands.

There is still a considerable demand for pure white lead, and the competition and watchfulness of the trade insure the genuineness of the article thus warranted by the manufacturers. The large class of customers, the grinders, who form a distinct trade, can use and mix the pure article with other substances and with coloring matters to suit their purposes. The mineral, sulphate of barytes or heavy spar, is the chief article used to adulterate white lead, and for this purpose it is obtained from mines in

Connecticut and other places, and is extensively ground in mills for this use alone. When perfectly pure, the powder is absolutely white; it has about the same weight as white lead, and is quite as indestructible; it is, indeed, less acted upon or discolored by noxious vapors. It lacks, however, the body of white lead, and is not so brilliant: hence it may be used in such proportion as to materially injure the paint in those good qualities. Oxide of zinc is also largely mixed with white lead, as will be noticed more particularly in the succeeding chapter.

The principal white lead works, together with the probable amount of their annual production, in the United States are as follows:—

	No. of Works.	Tons.
Brooklyn, N. Y.	3	6000
Staten Island, N. Y.	1	1000
Hudson River (Saugerties), N. Y.	2	1000
Buffalo, N. Y.	1	1000
Philadelphia, Pa.	2	3000
Pittsburg, "	1	
Baltimore, Md.	1	600
Boston, Mass.	1	1500
Salem, "	1	
Cincinnati, O.	2	
Louisville, Ky.	1	
Chicago, Ill.	1	
St. Louis, Mo.	1	

CHAPTER V.

ZINC.

While the production of the lead mines has been falling off in the United States, that of the zinc mines has been steadily increasing since they were first worked about ten years since; and the metal is applied to many purposes for which lead has heretofore been almost exclusively used. The growing importance of this product in the United States will justify a reference to the zinc manufacture of Europe.

The metal, as mentioned in the chapter on Copper, very curiously escaped the notice of the ancients, though they obtained it from its ores in preparing brass, an alloy of copper and zinc. In the metallurgical processes it is readily sublimed by heat, and when its fumes come in contact with the air they are immediately oxidized, burning with a greenish white flame, and are then converted into the white oxide of zinc—a compound of one equivalent of the metal = 34, and one of oxygen = 8; which correspond respectively to 81 and 9 per cent. These fumes when collected are found to be a white flocculent powder, now known as the white oxide of zinc, or zinc paint. If the vapor of zinc be protected from contact of air and passed through pipes into water, it is condensed into metallic drops, and these may be melted in close vessels and poured into moulds. Cast zinc is a brittle metal of bluish white color and greater lustre than that of lead. By heating it to the temperature of 212° to 300° F. it entirely loses its brittleness, and is made malleable and ductile, so that it can be rolled out into sheets. Its melting point is 680°, while that of lead is 608°.

A variety of ores are worked for this metal; as the sulphuret, called blende; the carbonate, called smithsonite; and the silicate of zinc, or calamine. The last two usually occur associated together. The red oxide is an important ore, but found only in New Jersey. Blende almost universally accompanies galena, and in some lead mines is the prevailing ore. The miners call it black jack. When pure, it consists of zinc 67, sulphur 33. Being more difficult to reduce than the other ores, it has been comparatively little used, though the Chinese are known to have been successful in their management of it. In the United States it lies valueless in immense quantities about many of the lead mines; but it is not improbable the old refuse heaps will yet be turned to profit. At the zinc works near Swansea, in Wales, it has been worked for many years; and in England it has for a few years past come into use. In 1855, it is reported that 9620 tons of this ore from various mines were sold; while of the calamine ores, the produce of the Alston Moor mines, sales of only 182 tons were reported. More ores of each sort were no doubt smelted, but the proportion of each was probably not very different from that stated. Dr. Ure, in his Dictionary, speaks of this ore selling at Holywell for £3 per ton. In France there are now five establishments working blende; while in 1840 all the zinc consumed in the country was imported. Smithsonite resembles some yellowish or whitish limestones, and usually accompanies these rocks, being irregularly bedded among their strata. In its best condition it is obtained in large blocks of botryoidal and reniform shapes, sometimes crystallized. But usually it is in porous crumbly masses, much mixed and

stained with reddish oxide of iron. The pure ore contains 65 per cent. of oxide of zinc (which is equivalent to 52 of the metal) and 35 of carbonic acid. The silicate of zinc is found intermixed with the carbonate, which it resembles in appearance. It contains, when pure, silica 25.1, water 7.5, and oxide of zinc 67.4, corresponding to 54 per cent. of the metal. The red oxide is found only at Mine Hill and Stirling Hill, near Franklin, in the extreme northern county of New Jersey. The pure oxide, of which it is almost exclusively composed, contains 80.26 per cent. of zinc and 19.74 of oxygen. The bright red color is probably derived from the small quantity of oxide of manganese present. The ore is mixed with franklinite iron ore, each being in distinct grains, one red and the other black; and with these is associated a white crystalline limestone, either in disseminated grains with the ores, or forming the ground through which they are dispersed. Two beds, consisting of the zinc and iron ores, lie in contact with each other along the south-eastern slope of the Stirling Hill, between the limestone of the valley and the gneiss of the ridge, dipping with the slope of these rocks about 40° toward the valley, and ranging north-east and south-west. The upper bed, varying from 3 to 8 feet in thickness, consists of more than 50 per cent. red oxide of zinc; and the lower bed, which is 12 feet thick and in some places more than this, is chiefly franklinite, changing to limestone below, interspersed with imperfect crystals of franklinite. At Mine Hill, 1½ miles north-east from Stirling Hill, two distinct beds are again found together, that containing the most zinc in this case being the under one of the two, lying next the gneiss. These localities have been well explored; the beds have been traced considerable distances along their line of outcrop; and at Stirling Hill the red oxide of zinc has been mined for more than ten years by the New Jersey Zinc Company. Their workings have reached to a depth of about 250 feet, and have afforded the finest specimens of zinc ore ever seen. A single mass of the red oxide was sent in 1851 to the Great Exhibition in London, which weighed 16,400 lbs., and attracted no little attention, from the purity, rarity, and extraordinary size of the specimen. The Passaic Mining and Manufacturing Company also have opened two beds of the same ore on their property at Stirling Hill, adjoining that of the New Jersey Zinc Company, and since June, 1854, have taken out about 30,000 tons of rich and lean ores. At the depth of 178 feet, the principal bed is 21 feet wide, of which about 2½ feet is rich ore, and the rest limestone sufficiently interspersed with oxide of zinc to render it worth dressing. This company have recently completed at the mines very extensive works for dressing the lean ores before they are shipped to their furnaces at Jersey City. The principal supplies of their ores for the last year have been of the smithsonite and calamine from the mines in the Saucon valley, Lehigh county, Pennsylvania, of which they have mined about 5000 tons during the year 1860. These ores are extensively worked to the north of Friedensville, both by this company and the Pennsylvania and Lehigh Zinc Company, whose furnaces are at Bethlehem, in Lehigh county. The mines of the two companies, which are near together, are known as the Saucon mine and the Lehigh Zinc Company's mine. They were first opened in 1853. The two kinds of ore are found together, as is common in the European mines, and more or less blende is interspersed among them. They form very large irregular beds in limestone of the lower Silurian period, and are penetrated by veins of quartz, which traverse both the ore and limestone. Huge masses of limestone lie interspersed among the ores. The deepest workings at the Saucon mine are about 100 feet below the surface; and from this depth galleries have been run in every direction, exposing to view more than 50,000 tons of ore. The ores of best quality are found in the lower workings.

About the same time that these mines were opened in Lehigh county, another, producing similar kinds of zinc ore, was discovered near Lancaster, in Pennsylvania; but after being explored it was found to contain so much blende and galena, that it was abandoned as worthless. Large deposits of the same varieties of zinc ore are known to exist in Tennessee; one locality at Mossy Creek, a few miles north-east of Knoxville, and another at Powell's river, a branch of the Clinch river, in Campbell county, about 40 miles north of Knoxville. These beds, examined by the writer in 1858, unquestionably contain very large quantities of excellent ore. The former, being close to the East Tennessee and Virginia railroad, is very conveniently situated; and the other

is within half a mile of a river navigable at certain seasons by flat-boats. Below its junction with the Clinch river are beds of bituminous coal, and the river is thence navigable by steamboats. At Kingston it is crossed by a railroad.

Very pure ores of similar character have been found in Arkansas. The localities are in a lead mining region in Lawrence, Marion, and Independence counties; but chiefly in the first named. The ores occur in a formation of magnesian limestone, imbedded in red ferruginous clay. They are almost exclusively smithsonite, containing very small proportions of silicate of zinc. Crystals of smithsonite and of blende are found upon the lumps of pure, flesh-colored ore. The district promises to become an important one for the supply of zinc to the western states.

The following are analyses of ores from the Saucon valley mines; the first three by Prof. John Torrey, of the New York Assay Office, being of specimens, and the last two of samples of large shipments. No. 4 was made at the Assay Office, Hatton Gardens, London; and No. 5 in Paris.

No. 1.

Oxide of zinc	48.90
Carbonic acid	26.40
Peroxide of iron	3.15
Carbonate of magnesia	.62
Silica	18.50
Water	.30
Loss	2.13
	100.00
Metallic zinc	39.30

No. 2.—*Granular Sulphuret of Zinc.*

Sulphuret of zinc	73.27
Sulphuret of iron	1.49
Silica	25.50
	100.26
Metallic zinc	49.09

No. 3.—*Waxy Sulphuret of Zinc.*

Sulphuret of zinc	97.63
Sulphuret of iron	1.54
Silica	1.40
	100.57
Metallic zinc	65.41

No. 4.—*Mixture of Blende and Carbonate of Zinc.*

Zinc	61.70
Sulphur	19.82
Iron	4.76
Silica	1.00
Carbonic acid	9.90
Phosphate of lime	.88
Oxygen, water, and loss	1.94
	100.00

Contains of silver 4.15 ozs. to the ton of 20 cwt.

No. 5.

Zinc	Carbonate of zinc, 75.1		42.0
Oxygen			10.5
Carbonic acid			22.6
Protoxide of iron	Carb. of iron, 10.2		7.3
Carbonic acid			2.9
Silica			11.8
Moisture			2.9
			100.0

METALLURGIC TREATMENT AND USES.

Zinc ores are applied to practical purposes, not only to produce the metal, but also the white oxide of zinc, which is largely employed as a paint. The ancients used an ore they called *lapis calaminaris*, to make brass, by melting it with copper in crucibles, not knowing that another metal was thus formed which produced an alloy with the copper. Although the metal was discovered in the 16th century, the nature of its ores was little known before the middle of the last century. It is now prepared upon a large scale in Belgium and Silesia, and small quantities are produced in England, France, and different parts of Germany. The simple method of obtaining zinc from its ores, called distillation *per descensum*, was introduced into England about the year 1740, and was derived from the Chinese, who appear to have been acquainted with the metal long before it was known to the Europeans. As now practised in Great Britain, the ores are first calcined, the effect of which is to expel a portion of the water, carbonic acid, and sulphur they contain. They are then ground to powder, and mixed with fine charcoal, or mineral coal, and introduced into stationary earthen pots, or crucibles. When set in the furnace, an iron pipe, passing up through the bottom of the hearth, enters the crucible, and connects with an open vessel directly beneath. About six pots are set together under a low dome of brick-work, through which apertures are left for filling them. Each one has a cover, which is luted down with fire clay; and the iron tube in each is stopped with a wooden plug, which, as the operation goes on, becomes charred and porous, so as to admit through it the passage of the zinc vapors. The tubes are prevented from being clogged with depositions of the condensed zinc, by occasionally running a rod through them from the lower end. The zinc collects in the dishes under the tubes, in the form of drops and powder, a portion of which is oxidized. The whole is transferred to melting-pots,

and the oxide which swims upon the surface of the melted metal is skimmed off and returned to the reducing crucibles, while the metal is run into moulds. The ingots are known in commerce as spelter.

In the United States zinc was first made by Mr. John Hitz, under the direction of Mr. Hassler, who, by order of Congress, was engaged about the year 1838 to manufacture standard weights and measures for the custom-houses. The work was done at the U. S. arsenal at Washington, the ores used being the red oxide of New Jersey. The expense exceeded the value of the metal obtained, and it has generally been supposed that we could not produce spelter so cheaply as it can be imported from Europe. The next experiments were made at the works of the New Jersey Zinc Company, 1850, on the Belgian plan. In these great difficulties were experienced for want of retorts of sufficiently refractory character to withstand the high temperature and the chemical action of the constituents of the ore. The franklinite, which always accompanies the red oxide ores, was particularly injurious by reason of the oxide of iron forming a fusible silicate with the substance of the retorts These trials consequently failed after the expenditure of large sums of money. The next important trial was made in 1856, by a Mr. Hoofstetter, who built a Silesian furnace of 20 muffles for the Pennsylvania and Lehigh Zinc Company at their mine near Friedensville. This proved a total failure, and seemed almost to establish the impracticability of producing spelter with the American ores, clays, and anthracite. About this time Mr. Joseph Wharton, the general manager of the Pennsylvania and Lehigh Zinc Company, and Mr. Samuel Wetherill, of Bethlehem, both hit upon the same plan of treating zinc ores in an open furnace, and leading the volatile products through incandescent coal, in order to reduce the zinc oxide so formed, and draw only metallic and carbonaceous vapors into the condensing apparatus. Mr. Wharton constructed his furnace in Philadelphia, and Mr. Wetherill his in Bethlehem. The former having completed his trials, filed a caveat for the process, but soon after abandoned it as economically impracticable. The latter continued his operations, patented the method, and produced some zinc, eight or ten tons of which were sold to the U. S. Assay Office in New York. The manufacture was not, however, long continued. In 1858, Mr. Wetherill recommenced the production of zinc, adopting a plan of upright retorts, somewhat like that in use in Carinthia, in Austria, and that of the English patent of James Graham. Mr. Wetherill had succeeded in procuring good mixtures of fire clays, and his retorts made of these and holding each a charge of 400 lbs. of ore, proved sufficiently refractory for the operation. The works now under his charge at Bethlehem, erected in 1858–9, and belonging to the owners of the Saucon mine, have a capacity of about two tons of metal daily.

Mr. Wharton, after abandoning the method of reduction by incandescent coals, continued his experiments on different plans, and finally decided on the Belgian furnace as the best, after having actually made spelter from silicate of zinc, with anthracite, in muffles of American clays, at a cost below its market value. These trials were made in the zinc oxide works of the Pennsylvania and Lehigh Zinc Company. Their success encouraged the company to construct a factory at Bethlehem for reducing zinc ores, and this was done under the direction of Mr. Wharton in 1860. The capacity of the works is about 2000 tons per annum, and their actual daily product in the winter of 1860–1, is over three tons. Four stacks or blocks are constructed, each containing four furnaces. To each furnace there are 56 retorts, making in all 896, working two charges in twenty-four hours. Their total capacity is about five tons of metal. Besides the ordinary spelter of this manufacture, which, as will be seen by the remarks that follow, is remarkable for its freedom from injurious mixtures, and is the best commercial zinc in the world, Mr. Wharton also prepares from selected ores a pure zinc for the use of chemists, and for purposes in which a high degree of purity is essential. This is cast in ingots of about nine pounds each, and is sold at the price of ten cents per pound. For the supply of chemists, and for the batteries employed by the telegraph companies, the American zinc of this manufacture is preferred to all others. The total annual consumption of crude spelter in the United States amounts to the value of about $600,000; and the value of sheet zinc, nails, etc., is about as much more.

The commercial zincs, it has long been known, are contaminated by various foreign substances, the existence of some of which

is indicated in the finely-divided black substance which remains floating or sinking in the liquid, when the metal is dissolved in dilute acids. The impurities have been stated by different chemists to consist of a great variety of substances, such as lead, cadmium, arsenic, tin, iron, manganese, carbon, etc. They injuriously affect the quality of the metal for many of its uses; and the presence of one of them, arsenic, is fatal to the highly important use of zinc by chemists, as a reagent in the detection of arsenic in other substances. Arsenic in the form of a sulphuret often accompanies the native sulphurets of zinc, and its oxide, being volatile, is readily carried over with the zinc fumes in the metallurgic treatment of blende, and may thus be introduced into the spelter. It is evidently, therefore, a matter of consequence to know the qualities of the different zincs of commerce, and the exact nature of the impurities they contain. Very thorough investigations having these objects in view have recently been made in Cambridge, Massachusetts, by Messrs. Charles W. Eliot and Frank H. Storer of Boston, and the results of these, with a full description of their methods of examination, were communicated, May 29, 1860, to the American Academy of Arts and Sciences, and published in the eighth volume of the new series of their Memoirs. Eleven varieties of zinc from different parts of Europe, and made from the ores of New Jersey, and of the Saucon valley, Pennsylvania, were experimented upon, of all of which large samples were at hand. These varieties were the following: 1, Silesian zinc; 2, Vieille Montagne zinc; 3, New Jersey zinc; 4, Pennsylvanian zinc, Bethlehem, Pennsylvania; 5, Vieille Montagne zinc, employed at the United States mint, Philadelphia; 6, zinc of MM. Rousseau, Frères, Paris, labelled and sold as *zinc pur;* 7, sheet zinc obtained in Berlin, Prussia; 8, zinc made near Wrexham, North Wales; 9, zinc from the Mines Royal, Neath, South Wales; 10, zinc from the works of Dillwyn & Co., Swansea, South Wales; 11, zinc from the works of Messrs. Vivian, Swansea. All of these, except the Pennsylvania zinc, furnished an insoluble residue, which was found to consist chiefly of metallic lead, and this proved to be the principal impurity of all the samples examined; "the carbon, tin, copper, iron, arsenic, and other impurities found in the metal by previous observers, occur either in very minute quantities, or rarely, and doubtless accidentally." The proportions of lead present in 100 parts of each of the varieties examined were respectively as follows: in No. 1, 1.46; 2, 0.292; 3, 0.079; 4, 0.000; 5, 0.494; 6, 0.106; 7, 1.297; 8, 1.192; 9, 0.823; 10, 1.661; 11, 1.516. The New Jersey zinc was found to contain a sensible quantity of tin, copper amounting to 0.1298 per cent., iron 0.2088 per cent., and an unusually large amount of arsenic. Traces of this were also detected in the white oxide prepared from the ores of the New Jersey mines, and in the red oxide ore itself; but the same ore afforded no clue as to the source whence the copper was derived, a metal of which not the slightest traces were discoverable in the other zincs. None of the samples contained sufficient arsenic to admit of its proportion being determined, and some were entirely free from it, as some of the Belgian and Pennsylvania spelter, but traces of it were met with in other samples from the same regions, indicating that the occasional use of inferior ores, such as blende, intermixed with the carbonates and silicates, might introduce this substance, or possibly it might come over only in the first part of the distillation, and the zinc collected in the latter part might be quite free from it. The Silesian zinc contained minute quantities of sulphur and arsenic; and the English zinc more arsenic than any other, except perhaps the New Jersey. The purest of all the samples was that from Bethlehem, Pennsylvania, some of it yielding no impurity, except a trace of cadmium. The source of a trace of arsenic in another sample is supposed to be in the use of the crust of oxide of zinc from the operations connected with the manufacture of white oxide of zinc, no particular care being taken in that process to reject inferior ores, and this crust being taken to the other works where the metal is prepared and mixed with the selected ores employed for this use, it has thus introduced the arsenic. As the authors of the paper remark, there seems to be no reason why zinc of uniform purity should not be obtained from the excellent ores of the Saucon valley mines.

EUROPEAN MANUFACTURE.

A large portion of the zinc of commerce is furnished by the works of the Vieille Montagne Company, established near the frontier of Belgium and Prussia, chiefly in

the province of Liege of the former country. A large number of mines are worked in this region, the most important of which is that of the Vieille Montagne or Altenberg, situated in the village of Moresnet, between Aix-la-Chapelle and the town of Liege. It is said that the great body of carbonate of zinc found here was worked as long ago as the year 1435, and that for four centuries it was not known that the ore was of metallic character, but it was used as a peculiar earth adapted for converting copper into brass. The ore lies in a basin-like depression in strata of magnesian limestone, and is much mixed with beds of clay intercalated among its layers. The ore is chiefly carbonate mixed with the silicate and oxide of zinc. Some of it is red, from the oxide of iron intermixed, and this produces only about 33 per cent. of metal. The purer white ore yields about 46 per cent., and is moreover much preferred on account of its working better in the retorts. The furnaces employed in the distillation of these ores are constructed upon a very large scale, and on a different plan from those in use in Great Britain. The general character of the operations, however, is the same. The ores are first calcined, losing about one fifth of their weight. They are then ground in mills, and charges are made up of 1100 lbs. of the powdered ore mixed with 550 lbs. of fine coal. The mixture being well moistened with water, is introduced into cylindrical retorts, which are three feet 8 inches long and 6 inches diameter inside, set inclining outward, to the number of 42 in a single furnace, and 4 such furnaces are constructed in one stack. The open end of each retort connects, by means of an iron adapter 16 inches long, with a wrought-iron cone, the little end of which, projecting out from the furnace, is only an inch in diameter. After the charges have been sufficiently heated, the sublimed zinc condenses in the neck of the retort and in the adapter and cone. The last two are then removed, and the zinc and oxide are collected from them, and the liquid metal in the neck of the retorts is drawn out and caught in a large ladle, from which it is poured into moulds. The zinc thus obtained is remelted before it is rolled. Two charges are run through in twenty-four hours, each furnace producing from 2200 lbs. of ore about 620 lbs. of metal, which is about 30 per cent. From a late report of these operations it appears that there are seven large smelting establishments belonging to the Vieille Montagne Zinc Mining Company, on the borders of Belgium and Prussia, comprising 230 furnaces. The annual product of these is 29,000 tons of spelter, of which 23,000 tons are converted into sheet zinc, and about 7000 tons are rolled at mills not the property of the company. They also manufacture oxide of zinc in three establishments devoted to this operation, to the amount of about 6000 tons annually. The company also purchases spelter very largely.

The metallurgy of zinc has, within a few years past, become an important branch of industry in Upper Silesia on the borders of Poland, and not far from Cracow. In 1857 there were no less than 47 zinc works in this part of Prussia, one of which, named Lydogniahütte, at Königshütte, belonged to the government, and the remainder were owned by private companies and individuals. In that year their total production was 31,480 tons of spelter, valued at about 17,660,000 francs. Many of the establishments belong to the Silesian Company, which also owns several coal mines near their works, and a number of zinc mines. The government works are supplied with ores from their own mines, and also from all the others, being entitled to one twentieth of their product. From a description of the operations published in the sixteenth volume of the *Annales des Mines*, fifth series, 1859, it appears that the processes are the same which had been employed for full twenty years previously, and each establishment presents little else than a repetition of the works of the others. The furnace in use is a double stack, furnished along each side with horizontal ovens, into each of which three muffles or retorts are introduced. These are constructed of refractory fire clays, and are charged, like the retorts of gas furnaces, by conveying the material upon a long charger or spoon into the interior. Their dimensions are about 4 feet long, 22 inches high, and 8½ inches wide, and the weight of the charge introduced is only about 55 pounds. The ovens on each side of the stacks contain as many as 20 and sometimes 30 retorts. The same stack contains besides, 1st, an oven in which the ores belonging to it are roasted for expelling the water and a portion of the carbonic acid they contain (a process in which they lose about ⅓ their weight); 2d, an oven for baking the retorts, each establishment making its own; and 3d, a furnace for remelting and purifying

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the zinc obtained from the retorts. Several stacks are arranged in a large building with close walls and open along the top of the roof to allow the smoke to escape. On one side, connected with it, are the workshops in which the muffles are made and various other operations are carried on.

The principal zinc mines are in the vicinity of Beuthen, and are found in the magnesian limestones of the new red sandstone formation. They are connected with the zinc works, which are principally near Königshütte, by branch railroads connecting with the principal line of road between Tarnowitz and Kattowitz. The ores are chiefly carbonates, always mixed with much oxide of iron, which is sometimes present to the extent of 20 per cent., and with them is also associated more or less silicate of zinc, blende, galena, and cadmium. Their percentage of zinc is very variable, rarely reaching 35, and probably averaging 21 or 22 per cent. Much that is worked does not exceed 12 per cent. They lie in irregular deposits, and it is found that their yield of zinc has been gradually falling off, so that it is now only about two fifths of what it was formerly. This low yield involves a large consumption of fuel, which is 20 tons for one of zinc obtained; and if this deterioration continues, the mines must some time hence be abandoned. The coal employed in working the ores is of poor quality, burning without flame; but it leaves no cinder, and is procured from mines very near the works, and at the extraordinary low price of 6 to 7 francs the 1000 kilogrammes (about one ton). The retorts are charged every 24 hours with roasted ore reduced to the size of nuts, and mixed with oxide of zinc from previous operations, with the dross from the crucible employed in remelting, with the incrustations from the muffles and their connections outside the furnaces, and in fine with cinders that have fallen through the grates, these last making about ¼ the bulk of the charge. The workmen having discharged a muffle of the liquid zinc and oxide remaining from the previous operation by drawing them forward, so that they fall upon an iron shelf placed below to catch them, and having repaired any cracks and holes in the muffle, they introduce the new charge in small portions at a time, and immediately adjust the outer connection, which is also of earthenware bent down at a right angle, and close up the openings in front. The zinc soon begins to distil over, and drops down upon the iron shelf, forming pieces of all shapes; and it is more or less mixed with oxide colored yellow by the oxide of cadmium. When remelted and run into moulds, the spelter is stated to have about the following composition: zinc, 97.50, cadmium, 1.00, lead, 0.20, arsenic, 0.84, sulphur, 0.05, together with traces of tin, iron, and carbon; but the character and proportion of the impurities are probably very variable. The expenses of the manufacture at the royal works amounted for the year 1856 to 48.60 francs the metrical quintal (220.47 lbs.), and in 1858 to 54.84 francs; consisting in the latter year of the following items: ore, 26.84; fuel, 14.30; labor, 7.00; materials employed, 3.70; general expenses, 3.00. The operations of the Silesian Company at their several works for the first half of the year 1858 are thus presented:—

COST OF THE SEVERAL ITEMS PER METRICAL QUINTAL OF PRODUCT.

Name of Works.	Ores treated. Met. quint.	Zinc obtained. Met. quint.	Cost of labor. Francs.	Fuel. Francs.	Ores. Francs.	Sundry expenses. Francs.	Total cost. Francs.
Gabor Silesia	112,399	19,703	4.98	10.35	11.40	4.27	31.00
Paulshütte	40,784	4,928	7.10	14.69	14.24	4.77	40.80
Thurzohütte	37,458	4,495	7.57	12.08	12.92	4.90	37.47
Friedenshütte	15,345	2,346	5.96	10.66	13.98	4.62	35.22
Stanislashütte	40,534	3,978	8.83	16.18	15.66	6.23	46.90
Carlshütte	45,918	5,723	6.06	14.80	13.23	6.91	41.00
	292,438	41,173					

The general consumption of spelter throughout the world is estimated in the report to which we have already referred, relating to the Vieille Montagne Company, to be about 67,000 tons, of which about 44,000 tons are sheet zinc applied as follows:—

	Tons.
For roofing and architectural purposes	23,000
" sheathing of ships	3,500
" lining packing cases	2,500
" domestic utensils	12,000
" stamped ornaments	1,500
" miscellaneous uses	1,500
	44,000

The estimate of 67,000 tons as the total annual production of zinc is probably too small for Europe alone. Taking the product above given of the works of the Vieille Montagne Company, viz., 29,000 tons, and that of the Silesian furnaces, 31,480 tons, there remain only 6,520 tons to be divided among the other zinc-producing countries. These are Poland, on the borders of Silesia, the annual production of which is usually given as 4000 tons; England, which has rapidly advanced from 1000 tons of spelter per annum to 6900 tons in 1858; Austria, which produces 1500 tons; Sweden, 40 tons; and the Hartz, 10 tons. Zinc, it is believed, is also manufactured to some extent in Spain. The European production would, therefore, seem to exceed 73,000 tons, and for the total production of the world, that of the United States and of China should be added. Of the extent of the manufacture of the latter country we know nothing. The United States produces of oxide of zinc and spelter over 7000 tons annually.

The value of the ores at different costs of the metal is given in the following recently prepared tab[illegible] from one of the European houses:—

SCHEDULE OF THE COST OF ZINC ORE ON SHIPBOARD AT ANTWERP.

Metal worth 50 francs the 100 kilogrammes.	Metal worth 55 f. the 100 kilogrammes.	Metal worth 60 f. the 100 kilogrammes.
Percentage of zinc by analysis.	Value of 100 kilogrammes. Francs.	Value of 100 kilogrammes. Francs.	Value of 100 kilogrammes. Francs.
CARBONATE OF ZINC.			
40	80.00	94.50	109.00
45	102.50	119.50	136.50
50	125.00	144.50	164.00
55	147.50	169.50	191.50
60	170.00	194.50	219.00
65	192.50	219.50	246.50
70	215.00	244.50	274.00
SILICATE OF ZINC.			
40	45.00	57.00	69.00
45	67.50	82.00	96.50
50	90.00	107.00	124.00
55	112.50	132.00	151.50
60	135.00	157.00	179.00
65	157.50	182.00	206.50
70	180.00	207.00	234.00

A kilogramme is equivalent to 2205 lbs. avoirdupois.

Fifteen years ago the quantity of zinc used for roofing did not exceed 5000 tons per annum, and no zinc was employed for sheathing ships, or lining packing cases. The stamped ornaments in this metal only came into use in 1852. In Germany zinc is now very generally used for roofing; and in Paris it has been employed for nearly every roof constructed during the last fifteen years. In laying the sheets great care is taken that the metal has sufficient room to expand and contract by change of temperature; and especially that it is fastened with zinc nails, and is allowed to come nowhere in contact with iron—even with nail heads. The purer the metal the longer it lasts. It is supposed the English do not apply it much to roofing on account of the poor success attending the use of bad metal, such as they manufacture from inferior ores.

Besides the uses named for this metal, it is employed for coating sheet iron, making what is called galvanized iron, though the use of the galvanic current is now dispensed with in its preparation; for pipes for conveying liquids; for baths, water-tanks, milk pans and pails, plates for engraving upon; for galvanic batteries; for nails, spikes, and wire, which is made of great flexibility and of all sizes. It has also been cast into statues, and made to imitate bronze. The Vieille Montagne Company sent to the Great Exhibition in London a statue of Queen Victoria, which with its pedestal of zinc was twenty-one feet high. Zinc is also an important reagent in chemical operations, and is especially employed with sulphuric acid to decompose water for obtaining hydrogen gas.

ZINC PAINT.

White oxide of zinc was first recommended as a substitute for white lead by the celebrated Guyton de Morveau about the close of the last century, during his investigations on the subject of lead poisoning; and to him it was suggested by Courtois, a manufacturer at Dijon. The high price of zinc at that time, and ignorance respecting the proper manner of using the oxide of zinc, prevented its introduction. It was many years after this that methods of producing it as cheaply as white lead were devised by M. Leclaire, a house-painter of Paris; and he also first prepared to use with it a series of yellow and green unchangeable colors, to replace those before in use having noxious bases of lead, copper, or arsenic; and also a drying oil, prepared by boiling linseed oil with about five per cent. of oxide of manganese. His process, which is still the one in general use in Europe, is based on the treatment of the metal instead of the ore, as practised in this country, and scarcely any white oxide of zinc is there made by

any other method. The furnaces employed are similar to those for producing the metal, or like those of the gas works. When the retorts set in these furnaces have become very hot, they are charged with the ingots of zinc. The metal soon melts, and its vapor passes off through the outlets of the retorts, where it meets a current of air, and both together are drawn on through the condensing apparatus either by the draught of a chimney, or by an exhausting fan at the further extremity of the apparatus. The metallic vapors become oxidized by mixing with the air, and are converted into a light, flaky, white powder, which is the oxide of zinc. The arrangements for condensing and collecting this are similar in principle to those employed for the same purposes in the American process. By making use of the metal in retorts, instead of subliming it from ores contaminated with their own impurities, and mixed with the coal required for conducting the process, a much purer oxide of zinc is obtained; and by selecting the purest sorts of spelter, the beautiful article, called by the French *blanc de neige*, or "snow-white," is produced, which is employed by painters in the place of the "silver-white." With the use of other zinc, the product is fit to be substituted for the best white lead. But if the metal has been made from ores containing cadmium or iron, or if old zinc has been introduced to which any solder adheres, according to the French chemists oxides of other metals are produced, and are taken up in small quantities with the zinc vapors, imparting to the oxide a slightly yellow or greenish tint, which if not very decided may however disappear when the paint is mixed; but the experience of American manufacturers does not accord with this explanation.

The manufacture of white oxide of zinc direct from the ore is a purely American process, established by the experiments of Mr. Richard Jones of Philadelphia in the year 1850. The great bodies of the rich ores of northern New Jersey had at various times, for the past two centuries, attracted the attention of many persons interested in metallurgical operations; and of late years numerous attempts had been made to devise some method of converting them to useful purposes. Zinc, however, was a metal not much in demand, and nothing was known of the useful qualities of the white oxide. When the value of this had been demonstrated in Europe, and the practicability of producing it economically from the red oxide was shown, a company was organized in New York under the name of the New Jersey Zinc Company, for the purpose of carrying on this manufacture upon a large scale. This association was incorporated by the Legislature of New Jersey, February 15, 1849, and the report of their operations, made December 31, 1853, by their president, C. E. Detmold, Esq., showed a production, for 1852, of 2,425,506 lbs. of oxide; and for 1853, of 4,043,415 lbs.; and the total production for 10 years, ending with 1860, has amounted to above 19,500 tons. Their works were established at Newark, N. J., to which place the ores are brought by the Morris and Essex canal; and the anthracite consumed in the manufacture is also delivered by water transportation. The company has forty furnaces, that may be kept in constant operation. The character of the process is like that which will be given below, as conducted by the Passaic Mining and Manufacturing Company.

The success of the enterprise of the New Jersey Zinc Company, and the discovery in 1853 of the great beds of silicate and carbonate of zinc in the Saucon valley, Pennsylvania, led to the organization in that year of the Pennsylvania and Lehigh Zinc Company, and the erection of furnaces for making the oxide at Bethlehem, on the Lehigh river. The operations were conducted by Samuel Wetherill, Esq., by a patented process of his own invention, and at a contract price of $50 per ton; the ore being delivered by the company at the works for $1.50 per ton. About four tons are consumed to the ton of oxide. The company have mined up to the present time about 60,000 tons of ore, and are manufacturing about 320,000 lbs. of oxide of zinc per month.

A third company was established in 1855, called the Passaic Mining and Manufacturing Company, and their works, constructed at Communipaw, on the Morris canal near Jersey City, went into operation in June of that year. They obtain their ores both from the mines of red oxide in Sussex county, and from the Saucon valley mines in Pennsylvania. They employ 24 furnaces, built in 3 stacks, of 8 each, in which they are arranged like ovens, half of them opening on one side and half on the opposite side. Each one is about 6 feet in depth (from front to back), 4 feet in width, and

about 3½ feet in height. The roof is arched, with an opening through it for the pipe which conveys away the vapor and products of combustion. The sole is formed of cast-iron plates, which are perforated full of small holes for admitting the blast to penetrate every portion of the charge, as the wind is driven by two large fan-blowers into the receptacle under the furnace corresponding to the ash pit. The ores are prepared by first crushing them to powder, which is done by passing them through two pairs of Cornish rolls, and then mixing them thoroughly with about half their weight of the dust of anthracite. A fire is kindled upon the grate-bars of 250 lbs. of pea coal, and when ignited to full whiteness the charge of 600 lbs. of ore, mixed with 300 of coal dust, is added, and when exhausted the charge is withdrawn, leaving only sufficient coal to ignite the next charge, thus working off 4 charges in every 24 hours. The proportion of oxide obtained from the ore is variable, as the charge is not of uniform quality; but it is usually between 30 and 40 per cent. As the coal rapidly consumes from the effect of the blast, the ores are decomposed, and metallic zinc sublimes. The vapor rises with the gaseous products of combustion, and all are carried up the pipe, which just above the roof of the stack terminates under an inverted funnel, the base of which covers the lower pipe like a hood, and the upper portion is a pipe like that below. A strong current of air is created by two exhausting fan-blowers at the other extremity of the apparatus, and the vapors are drawn up together with much air which flows in around the open base of the funnel, and causes at this point a vivid combustion of the zinc vapors, which burn with a pale blue flame, and are thus converted into oxide. The appearance presented by this combustion actively going on in full view under each hood is very striking, and is far from suggesting to an observer unacquainted with the process, the possibility that from the pale flames rushing up the pipes any valuable product can be recovered. The pipes connect above with a cylindrical sheet-iron receiver that extends over the three stacks, so as to secure the products of all the furnaces. It is a huge pipe, 6½ feet in diameter, and 130 feet long, and passes along under the roof, against a line of windows on each side, through which air is admitted for hastening the cooling of the products. The pipe discharges into a square tower in masonry, and in this the particles are washed and cooled by a continual falling sheet of water. The light flocculent oxide of zinc is not carried down by this to any great extent, but is drawn on by the exhaust through 3 large pipes to a second tower with three divisions, in which the fans are placed that create the draught. From this the current, still propelled by the fans, moves on through other pipes that connect with the system of flannel bags, which in great numbers, and of extraordinary sizes, are suspended throughout the portion of the building devoted to the final cooling of the oxide, and filtering it from the gaseous matters intermixed. Some of the bags extend the whole length of the rooms, which are 120 feet long by 64 wide, and the diameter of the largest of them is over 4 feet. They are arranged near together, and some are carried vertically from the horizontal ones up to the roof. Through the pores of the flannel the gases escape, and the oxide of zinc remains thoroughly purified. Nearly 200,000 square feet of flannel are worked into these bags; and one person is almost constantly employed with a sewing machine, and two others working by hand, in making and repairing them. Along the under side of the horizontal bags pipes of cotton cloth, ten or twelve inches in diameter, reach down nearly to the floor, and are kept tied around their lower ends. These are called the teats; and the oxide of zinc is collected by lifting up the portions of the bags where it has settled, and shaking these so as to make it fall into the teats. The ends of these are then opened, and the white zinc is received in strong bags, which being tied up are laid upon a truck, and this is run by steam power back and forth under a compressing roller. The air dispersed through it, rendering it so light and bulky, is thus expelled, and the oxide is converted into a dense, heavy powder. The last process is to grind this with bleached linseed oil, which is done in the ordinary paint mills. The paint is then transferred into small kegs for the market.

The residuum of the furnace charge, when of red oxide, consists of some unsublimed zinc ore mixed with franklinite and more or less unconsumed coal. It is raked out in the form of slags, and is accumulated in immense piles about the works. In 1853, Mr. Detmold succeeded in using this as an iron ore, and produced excellent iron which proved to be also

well adapted for the manufacture of steel. The iron manufacture has been continued, and has become a profitable branch of the operations of the United States Zinc Company, producing about 2000 tons of zinc per annum. The franklinite itself had been used a year earlier for the same purposes by Mr. Edwin Post, at Stanhope, and from this he obtained both iron and steel; but when the manufacture was undertaken upon a large scale by the New Jersey Franklinite Company, at Franklin, New Jersey, it proved unsuccessful in practice.

The product of the zinc works of the Passaic Company for the year 1856, was 2,327,920 lbs. of oxide of zinc; and the monthly production for the year 1860 has been about 400,000 lbs. from 16 furnaces. With the 24 in blast their monthly capacity is from 280 to 300 tons of 2000 lbs. to the ton. The total annual product of the three establishments is from 6000 to 7000 tons of oxide; and the consumption of this large quantity in the United States is good evidence of the importance of this paint, and of the great extent to which it must have superseded the use of white lead.

The items which make up its cost are of such nature that no exact estimate can be given of this. The ores are of no definite composition, and according to their percentage, as obtained from the mine or afterward dressed, the quantity required to produce a ton of oxide must vary, while with poor ores a proportionably larger amount of fuel is consumed than that required for rich ores. These items consequently vary between considerable extremes; and then the cost of the bags, barrels for packing, and the numerous incidentals, including repairs and general expenses, can only be arrived at by a careful computation of the operations of each establishment. The market price of the oxide is from 4½ to 5½ cents per lb.

The importance of the application of white zinc to painting in the place of white lead appears to have been much more fully appreciated in France and the United States than in Great Britain. Soon after the discoveries of Leclaire that white oxide of zinc could be thus used, and produce, with the colored bases he prepared of this and other innocuous oxides, all the tints required, the French government, recognizing the importance of his inventions, conferred upon him the cross of the Legion of Honor, and adopted the paints for the public buildings. By the year 1849, over 6000 public and private buildings had been painted with his preparations, and the testimony was very strong in their favor. Not one of his workmen had been attacked by the painter's colic, though previously a dozen or more suffered every year from it. The colors were pronounced more solid and durable than the old, were made brighter by washing, and were not tarnished by sulphuretted hydrogen, as occurs to white lead. The best white paint was moreover so pure and brilliant a white, that it made the best white lead paint by its side look disagreeably yellow and gray. No difficulty was experienced in making the new colors, mixed with the prepared oil, dry rapidly without the use of the ordinary dryers of lead compound; and used in equal weight with lead, the zinc was found to cover better, and was, consequently, more economical at equal prices per lb. The English, however, found many objectionable qualities in the new paint. Its transparency, which is the cause of its brilliancy, by reflecting instead of absorbing the light, was regarded as a defect, and the painters complained that it had not the body or covering properties of the carbonate of lead. It would not dry rapidly for the second coat without the use of the patent dryers, which contain lead, and therefore it was no better than the lead. Messrs. Coates & Co., who now import into Great Britain about 1000 tons of oxide of zinc per annum, wrote to the editor of the *Lancet* in March, 1860, that the consumption of white lead is still nearly 100 to 1 of white zinc, and that in 1856 the importation of the latter amounted to only 235 tons. They ascribe the real cause of the larger consumption of white lead, to the almost entire exclusion of zinc, to the fact, that white lead can be adulterated with barytes and other cheap ingredients without the adulteration being detected by the eye, thus securing large profits to the manufacturer and contractor, which cannot be realized in the use of zinc paint, for the reason that it has little affinity for foreign substances. The experience of the manufacturers of the United States does not substantiate this statement as to the difficulty of using the oxide of zinc in mixture with other substances. It is employed not only alone, but mixed with either barytes or white lead, or with both of them; and large quantities are thus sold and give satisfaction to consumers, who would reject the paint, if they supposed it to be any thing else than white lead. As to its

covering quality, it is found that the oxide of zinc varies according to the manner in which it has been prepared. The light flocculent oxide mixes readily with oil without grinding; but though pressed, it covers much less surface than the same oxide moulded when moistened with water, and dried by artificial heat. This preparation also causes any yellowish or greenish tints to disappear, and the article may be supplied to the consumer in cakes, which when ground with oil will cover more surface than the same weight of white lead. The body of the white zinc may be still further improved by calcination before grinding.

The inferior colored sorts of oxide of zinc, such as are collected in the iron receivers near the furnaces, and that made from the pulverized ores of zinc, have been largely employed for painting iron surfaces, especially on board of ships, the paint being found to possess a peculiar quality of protecting the iron it covers from rusting.

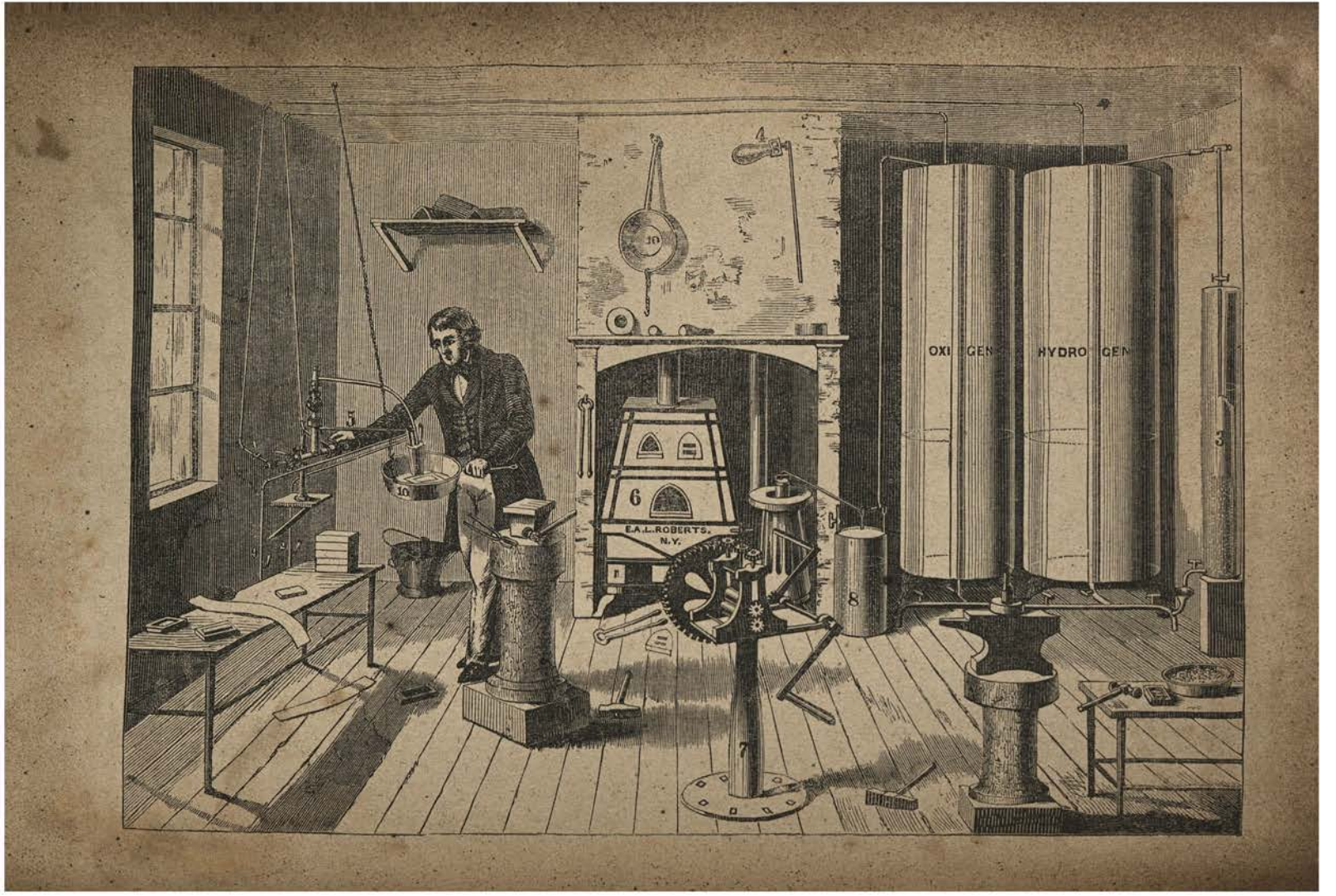
Besides its use as a paint, oxide of zinc is applied to the preparation of the mastic for rendering metallic joints tight; and to that of glazed papers and cards, for which white lead and carbonate of barytes have heretofore been used. The French use it in preparing the paste for artificial crystals instead of oxide of lead or other metallic oxides; and they have also made with it some of the finest sorts of cut glass and especially lenses. In the Great Exhibition of 1851, an award was made to specimens of zinc glass which presented a very pleasing and white appearance, and were regarded as especially suited to achromatic purposes. It was remarkable for its being purer and more pellucid than lead glass, and also of greater specific gravity.

A patent has been granted in the United States for the manufacture of flint glass with oxide of zinc, and specimens of glass were produced with it in 1860, which were remarkable for their brilliancy and beautiful surface, or "skin," as it is called. The glass is more infusible than that made with oxide of lead, and there seems to be no good reason to prevent it coming rapidly into use.

CHAPTER VI.

PLATINUM.

Although this metal is not obtained in large quantity in the United States, it is found associated with the gold in many localities in California and Oregon, and has been detected in Rutherford county, North Carolina, and in traces in the lead and copper ores of Lancaster county, Pennsylvania. From the states on the Pacific it has been supposed that it would yet be afforded as a commercial article. It is a metal of considerable interest from the extent to which it is used in the United States, and the success that has attended the attempts to work it in Philadelphia and New York. The metal is supplied to commerce from no certain source, and finds its way into the United States in a great variety of forms, as in native grains found in washing the gold deposits of Cauca on the western coast of South America, of Brazil, and Oregon, and in manufactured articles imported from Europe and chiefly from France. Russia produced between the years 1824 and 1845 many times as much platinum as all the rest of the world, and introduced the metal into her coinage; but after 1845 it was no longer coined, and the yield of the deposits in the Ural has dwindled away to almost nothing. The supply from Borneo has been very large for some years, the whole product of the island sometimes amounting to 600 lbs. a year. It is found in small grains and lumps in the sands that are washed for gold; and pieces of several pounds have been met with in Siberia, the largest weighing over 22 lbs. troy. The properties which give to the metal its great value, as its power of resisting the effects of heat and many of the most powerful chemical agents, also render it exceedingly difficult to work and to convert into useful shapes. The crude grains are generally alloyed to the amount of about 20 per cent. of their weight with the very refractory metal iridium, with osmium, rhodium, iron, and sometimes other metals also. It is separated from the chief part of these and purified by dissolving the grains in *aqua regia*, a mixture of nitric and hydrochloric acid, and causing the metal to be precipitated by sal-ammoniac. It falls in a yellowish powder, which is a compound of platinum, ammonia, and chlorine. To decompose this the compound is separated from the liquid, and being well washed and dried, is heated red hot in a cast-iron crucible. This drives off the ammonia and chlorine, and the platinum remains in the crucible in a spongy condition. This is condensed into solid metal by repeated heatings and hammerings. It has always been a matter of great difficulty to raise


OXI GEN
HYDRO GEN
E.A.L. ROBERTS.
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sufficient heat to soften the platinum, even in quantities less than an ounce, so that it could be worked under the hammer. It used formerly to be brought into a metallic cake by making a fusible alloy of it with arsenic, and then burning out the latter as much as possible, and hammering or rolling the cake into sheets, but the arsenic remaining in the platinum always injures its quality. Dr. Robert Hare, of Philadelphia, was the first to fuse the metal for any practical purpose, and in May, 1838, he exhibited a cake of about 23 ounces, which was run together from grains and scraps by means of the intense heat produced by his oxy-hydrogen blowpipe. From a reservoir of oxygen, and from another of hydrogen, a gas-pipe conveyed the gases into one tube, in which they were mixed just back of the igniting jets; and in this the explosive mixture was kept cool by ice around the tube. Explosion was moreover guarded against by the extreme fineness of the apertures through which the gases were made to pass.

This means of working platinum has been applied very successfully by Dr. E. A. L. Roberts, of Bond street, New York, in the preparation of platinum plate and various articles in this metal employed by dentists, such as the plates and fastenings for sets of artificial teeth, and the little pins which secure each tooth in its setting. The annual consumption of these last, it is estimated, amounts throughout the United States to about $60,000 in value, which is nearly ½ of the annual supply of the metal. The apparatus consists of two cylindrical copper gas-holders, one for hydrogen, holding 220 gallons, and one for oxygen, holding 80 gallons. The Croton water, with a pressure of about 60 lbs. upon the square inch, is admitted into the bottom of these gas-receivers, for propelling the gases as they are required. The discharge pipes have each at their extremity a short brass tube, which is full of pieces of wire of nearly the same length as the tube, jammed in very tightly. These unite in another brass tube which is packed in a similar way, and connects by a metallic pipe of only ¼ inch bore, with the burner. This is a little platinum box, one end of which terminates in a disk of platinum or copper ½ by ½ inch in size, perforated with 21 very minute holes in 3 rows. This box is buried in plaster of Paris mixed up with fibres of asbestus, forming a lump sufficiently large to contain around the box a receptacle into which, by means of flexible pipes, a current of water is admitted and discharged on the same principle that the water-tuyeres of iron forges and furnaces are constructed and kept cool while in use. The burner points downward, so that the jet is directed immediately upon the face of the metal held up beneath it. The method of using the apparatus is as follows: the platinum scraps being first consolidated by pressure in moulds into compact cakes of 10 to 20 ounces each, these are placed upon a plate of fire-brick, and brought to a full white heat in a powerful wind-furnace. The plate with the platinum is then removed from the furnace and set in a large tin pan thickly lined with asbestus and plaster of Paris, and is brought directly under the jet, which at the same time is ignited. The platinum immediately begins to melt upon the surface, and the pieces gradually run together into one mass as the different parts of the cakes are brought successively under the jet. Though the metal melts and flows upon itself, it cools too rapidly to be cast in a mould; nor is this necessary or desirable for the uses to which it is applied. These require a soft and tough material, while the fused metal is hard and sonorous, and of crystalline texture, breaking like spelter. It is made malleable and tough by repeated heatings and hammerings. It is introduced into the muffle of the assay furnace constructed by Dr. Roberts especially for producing the high heat required in these and similar operations, and is heated so intensely that when the door of the furnace is opened the cake of metal is too dazzlingly hot to be visible. It is then taken out with tongs plated with platinum, and hammered with a perfectly clean hammer upon a clean anvil, both of which should be as hot as possible without drawing the temper of the steel. If the process is one of welding, when the platinum has cooled so as to be distinctly visible, it should be heated again, for in this condition every blow tends to shatter and shake it to pieces. The lump is forged by hammering it to a thickness of about ¼ of an inch, and then being again heated very hot, is passed instantly through the rolls. It is thus obtained in sheets, which are easily converted into the various uses to which the metal is applied.

Upon the opposite page, the apparatus employed and manner of conducting the operations are exhibited in the wood-cut;

and the articles designated by the figures are thus explained:—

1. Reservoir for oxygen.
2. " " hydrogen.
3. Hydrogen generator.
4. Oxygen "
5. Blowpipe.
6. Tuyere.
7. Rolls for converting the metal into sheets.
8. Gasometer.
9. Water pipes.
10. Pan.
11. Moulds in which the loose pieces of metal are compressed.

Crucibles for chemical use are prepared by the ingenious method called spinning. A disk of the metal is securely fixed against the end of the mandrel of a lathe, and, as it revolves rapidly, a blunt point is pressed upon its surface, causing the plate to gradually bend over and assume the desired form. The large platinum retorts used in the manufacture of sulphuric acid are imported from Paris. The whole amount of platinum brought to the United States for the year 1850 was 34,000 oz. troy, which, at the custom-house valuation of $6.10 per oz., amounts to $200,000. Probably the whole amount of native metal worked over does not exceed 1500 oz. The amount of scraps remelted by Dr. Roberts is about 1000 oz. a year.

IRIDIUM AND OSMIUM.

An alloy of these metals in fine grains of excessive hardness is found very frequently with platinum and with the gold which is refined at the mints. It is of interest from the use to which it is applied in forming the nibs of gold pens; and for this purpose the small grains are purchased by the pen-makers sometimes at the rate of $250 an ounce. From this quantity they may select from 8000 to 12,000 points of suitable size and shape for use. The alloy is known as iridosmium, and is also very generally called iridium. At some seasons it has been quite abundant in the gold presented at the New York assay office; but recently it is more rare. As it does not fuse and alloy with the gold, it appears in specks upon the bars of this metal. The method of separating it is to melt the gold with a certain portion of silver, as in the usual refining process. The alloy thus obtained being less dense than the melted gold, the particles of iridium settle in the lower portions; the upper is then ladled off, and the metals are parted. More of the impure gold is added, and the process thus goes on till a considerable amount of iridium is concentrated into the alloy of gold and silver, from which it is at last obtained by dissolving these metals. According to the statement of Dr. Thèvenet published in the *Annales des Mines* (vol. xvi., 1859), iridium is collected at the gold-washings along the sea-coast of Oregon, and is sometimes quite equal in quantity to the gold. He describes it as white, glistening, very heavy, its specific gravity being 20 to 21, very hard, and resembling sand, its angles slightly flattened and rounded by friction. It is accompanied by platinum and rhodium. After one of the storms that prevail along this coast, the miners at low tide collect the black sand and carry it to the washing and amalgamating apparatus, in which it is stirred with mercury and then treated upon the shaking tables. Though by their rude processes they probably lose ¼ of the precious metals, they sometimes collect several ounces a day of gold to the man. Near Fort Orford, to the north of Rogue River, about 15 per cent. of iridium is found with the gold. Still further north, between Cape Blanco and Coquille, the metals collected consist of about 45 per cent. iridium and 5 per cent. platinum. Between Randolph and Cape Arago the metallic grains are very light and in extremely thin scales; they consist of 70 per cent. iridium and 6 per cent. platinum. Further north, the iridium continues almost as abundantly, but mostly in very fine particles. One piece was shown to Dr. Thèvenet as a great curiosity which was as large as a grain of rice. In sifting more than 50 lbs. of iridium, he states that he had not seen a single specimen of one quarter this size.

CHAPTER VII.

MERCURY.

This metal, which is extensively employed in the arts, especially in the treatment of gold and silver ores by amalgamation, in the combination of amalgams for coating mirrors, etc., in the construction of barometers and thermometers, and other philosophical instruments, in the manufacture of the paint called vermilion, for several medicinal preparations, and for a variety of other purposes, was not classed among the productions of the United States until after the acquisition of Califor-

nia, when mines of its principal ore were opened, which have been extensively worked, as will be described below. Mercury, which is the only fluid metal, is found both in a native state, dispersed in drops among the slates that contain the veins of its ores, and also occurs in combination with sulphur in the ore called cinnabar, a compound of one atom of mercury and one of sulphur, or of 86.2 per cent. of the former, and 13.8 per cent. of the latter. Some other natural compounds are known, which are not, however, of much importance. Cinnabar is almost the exclusive source of the metal. This is a very heavy, brilliant ore of different shades of red; is readily volatilized at a red heat, giving off fumes, when exposed to the air, both mercurial and sulphurous; but in tight vessels it sublimes without decomposition, and if lime or iron be introduced with the ore into retorts, the sulphur is retained in combination with the new element, and the mercury escapes in vapor, which may be condensed and recovered in the metallic state. On this principle the process for collecting mercury is based. The ores of mercury are found in almost all the geological formations, but the productive mines are only in the metamorphic or lowest stratified rocks, and in the bituminous slates of the coal measures.

In order to appreciate the importance of the mines of California, it is necessary to understand the extent of the demand for this metal, and the sources which have supplied it. From the time of the ancient Greeks and Romans, mercury has been held in high estimation, and has been furnished from the same mines, which have ever since produced the chief part of the product of the world. Pliny states that the Greeks imported red cinnabar from Almaden in Spain, 700 years before the Christian era, and in his own time it was brought to Rome from the same mines to the amount of 700,000 lbs. annually. In modern times the production amounts to 2,700,000 to 3,456,000 lbs. per annum, and is chiefly obtained from two veins, one about 2 feet, and the other 14 feet thick, which, meeting in a hill about 125 feet high, spread out to a thickness of nearly 100 feet. The ores are of small percentage, yielding about $\frac{1}{10}$ only of mercury. The greatest depth of the workings was only about 330 yards several years ago. After the metal has been extracted from the ores, it is packed in iron bottles or flasks holding 76½ lbs. each, and is taken to Cadiz for shipment. For many years past, the lessees from the Spanish government, in whom the title is vested, have been the Rothschilds and other bankers of Europe; but their contracts with the government have varied from time to time, thus affecting the price at which the product was held.*

The mines next in importance have been those of Idria in Carniola, belonging to the Austrian government. These, for some years previous to 1847, had produced an annual average of 358,281 lbs. of mercury, and since that time, the production has varied, sometimes reaching 600,000, and even over 1,000,000 lbs. per annum. The other mines of Europe do not probably produce 200,000 lbs. On the American continent many localities of the ores have been worked to some extent; but although the consumption is very great at the silver mines of Mexico, amounting, as estimated by Humboldt, to 16,000 quintals of 200 lbs. each, three fourths of the supply was then derived from the European mines. In 1782, mercury was even brought to South America from China, where it was formerly largely extracted in the province of Yunnan. Yet in the early years of the Spanish conquest Peru was a large producer of the metal, its most important mines being in the province of Huancavelica, where no less than 41 different localities of the ore have been known; but at present the whole product of the country is supposed not to exceed 200,000 lbs. A large portion of this product is from the Santa Barbara, or the "Great Mine," which has been worked since 1566. The mines of Chili and the numerous localities at which the ores have been found in Mexico supply no metal of consequence. Dumas estimated, not long since, the total annual production as follows:—

	lbs. avoirdupois.
Almaden, Spain	2,700,000 to 3,456,000
Idria	648,000 " 1,080,000
Hungary and Transylvania	75,600 " 97,200
Deux Ponts	42,200 " 54,000
Palatinate	19,400 " 21,600
Huancavelica	.. 324,000
California	.. 2,000,000
Total	7,032,800

* In 1839 the royalty demanded by the government was $59 per quintal of 106 lbs., to which it had reached by successive advances from $51.25; and in 1843 it had advanced to $82.50 per quintal. The opening of the California mines soon caused this to be considerably reduced.

In California the existence of large quantities of cinnabar was known long before the real character of the ore was understood. It was found along a range of hills on the southern side of the valley of San José, about 60 miles south-east from San Francisco. For an unknown period the Indians had frequented the locality, coming to it from distant places, even from the Columbia river, to obtain the bright vermilion paint with which to ornament their persons. With rude implements, such as the stones they picked from the streams, they extracted the ore from the flinty slates and shales in which it was found, and in their search for it they excavated a passage into the mountain of about sixty feet in length. In 1824 the attention of the whites began to be directed to this curious ore, and some of the Mexicans sought to extract from it gold or silver. Other trials made of it in 1845 resulted in the discovery of its true character, and operations were thereupon commenced to work it by one Andres Castillero. Owing, however, to the disturbed state of the country, little was done until 1850, when a company of Mexicans and English engaged vigorously in the extraction and metallurgical treatment of the ore, and established the mine which they called the New Almaden. In 1858 a stop was put upon their further proceedings by an injunction issued by the United States court on the question of defective title. From the testimony presented in the trial, it appeared that the company in the course of eight years had produced full 20,000,000 lbs. of metal, and realized a profit of more than $1,000,000 annually. The Americans who claimed the mine directed their attention to the discovery of new localities of the ore, and succeeded in finding it upon the same range of hills within less than a mile of the old workings. Here they opened a new mine in December, 1858, which they named the Enrequita, and in June, 1860, a company was formed in New York for working it under the name of the "California Quicksilver Mining Association." The following are the returns of their operations to the latest dates: in September, 1859, the product of mercury was 14,400 lbs.; October, 28,650; November, 27,525; December, 28,425; January, 1860, 27,000; February, 16,950; March, 25,500; April, 33,700; May, 46,275; June, 48,750; July, 50,000; August, 79,866; September, 66,096. The increase of production, hereafter, will be limited rather by the capacity of the reducing apparatus than by that of the mine. Twenty-four retorts for distilling the mercury are now in operation, 6 of which have been started since August, 1860. From the report of October 11, 1860, it appears that a new vein has also been opened, in which 20 men are employed, working in solid cinnabar without having encountered the boundary walls of the lode. The total expenditure for mining, for machinery, etc., up to October 15, 1860, had amounted to $275,000, all of which has been paid out of the proceeds of the mine, leaving a considerable balance on hand. The company owns another mine also, called the Providencia, which has produced some cinnabar.

The operations at the Enrequita mine are carried on from the face of the hill, some 5 or 6 levels one above another being carried into the mountain up and down its slope. The most extensive of these is the adit level at the base, which is about 600 feet long. Shafts are sunk from this to the depth of about 50 feet; but the principal workings are in the upper levels for 300 feet over the adit. These are exceedingly irregular, owing to the unequal distribution of the ore through the argillaceous slates. It lies in beds included between the strata of these lower silurian rocks, dipping with them at a very steep angle, and winding with the contortions of the strata. The workings follow the bunches of ore as they lead up or down, and to the right or left. Shafts occasionally penetrate from one level to another, but no regular system of working appears to have been adopted. With the cinnabar is intermixed some arsenical iron and copper pyrites, and the ore and slates are both traversed by veins of carbonate of lime, some of which are retained in hand specimens of the cinnabar.

On the same range of hills, at its western extremity, the Santa Clara Mining Company, of Baltimore, has opened a mine called the Guadalupe, the product of which for the year 1860 was about 200,000 lbs.

The total production of the quicksilver mines, derived from the custom-house returns and the supposed consumption of 35,576 flasks in California, has been estimated to amount, from the commencement of 1853 to near the close of 1858, to about 177,578 flasks, or 13,318,350 lbs.

NEW ALMADEN QUICKSILVER MINE.

METALLURGIC TREATMENT.

From cinnabar not contaminated with strange metals, the method of obtaining the fluid mercury is very simple. In the early workings of the New Almaden mine, the clean ores were placed in the common "try pots," such as are used by the whalers, and a cover being tightly luted on, a fire was started under them, and the mercurial vapors escaped through a tube inserted in the lid and were condensed in cold vessels. Afterward furnaces were constructed in brick-work upon a large scale, each one provided with a chamber or oven 7 feet long, 4 feet wide, and 5 feet high, corresponding to the chamber of the reverberatory furnaces; and into this was introduced a charge of 10,000 lbs. of clean ore separated from the poorer portions after the whole had been broken up. With the ore was mixed a portion of lime to combine with and retain the sulphur. A partition of brick-work separated the oven from the fire-room, and the bricks in this partition were so laid as to leave open spaces for the flame from the burning wood to pass through. On the opposite side of the oven another partition separated this from a chamber of its own size, the only communication between them being by a square hole in one of the corners close to the roof. This chamber connected with another by an opening in the opposite corner near the floor, and this arrangement was extended through eight chambers. Between the last one and the tall wooden flues through which the smoke and vapors finally passed out into the open air was placed a long wooden box provided with a showering apparatus. As the cinnabar was volatilized by the flame playing over the charge, the vapors were carried through the condensing chambers, depositing in each a portion of mercury, and in the showering box they underwent their final condensation. From the bottom of each chamber the metal flowed in gutters to the main conduit which led to the great iron reservoir sunk in the ground. From this it was poured into flasks through brushes which intercepted the scum of oxide of mercury. The method proved very wasteful, from the leakage of the vapors through the brick-work; and it has been abandoned for an improved process, in which the pulverized ores mixed with quicklime are charged into large cast-iron retorts very similar in their form and setting to those employed at the gas-works. Three are set together in a bench of brick-work, and each one is furnished with an eduction pipe inserted in the end and leading down into water contained in a large cylindrical condenser of iron. This is placed along the front line of the furnace, so as to receive the vapors from all the retorts. The mercury, as it is condensed, falls down to the bottom, and is let out through a pipe by a contrivance that prevents the water flowing with it from the condenser. At the Enrequita mine each bench of three retorts requires a little over a cord of oak wood a day for heating. Four benches, in operation from September, 1859, employed 6 men in charging and discharging, working in 2 shifts of 3 men, besides 3 firemen, each working 8 hours. Two men besides these were employed in mixing the ores for the retorts. In June, 1860, the production of these furnaces, from 1000 cargas of ore of 300 lbs. each, was about 50,000 lbs., or about 17 per cent.

In conducting the furnaces, the workmen are seriously affected by inhaling the mercurial vapors. They are sometimes even salivated, and are often obliged to abandon the business for a time. The horses and mules also suffer from the noxious fumes, and many are lost in consequence. But no injurious effects are experienced among those employed in the mines, the cinnabar being always handled with impunity.

The view of the works presents their appearance in 1852, as sketched by J. R. Bartlett, Esq. It was first published in his "Personal Narrative" (New York, 1854).

USEFUL APPLICATIONS OF MERCURY.

The principal uses to which mercury is applied have already been named. The largest quantities are consumed in working gold and silver ores. The principle of the amalgamating process is explained in the account of the treatment of gold ores. In the arts amalgams are applied to many useful purposes, of which the most important is coating the backs of looking-glass plates with tin amalgam. Silver was originally employed instead of tin, and the process is still called "silvering." It is conducted at several establishments in the United States on the old Venetian plan, which has been in use for 300 years. The largest mirrors are prepared by Messrs. Roosevelt & Sons, in New York, from the French plates which they import. The process is a simple one,

but is attended with some difficulties arising from the imperfections which will sometimes appear upon the coating, notwithstanding the particular care taken to avoid them. The health of the workmen also suffers, so that they cannot pursue the business more than a few years. The only precaution taken to protect them from the effects of the mercury is thorough ventilation. Frequent use of sulphur baths also is very beneficial. The method of silvering is as follows: tables are prepared of stone made perfectly smooth, with grooves sunk around the edges. These are set horizontally, but can be raised a little at one end by a screw. Each table is covered with tinfoil carefully spread out over a larger surface than the plate will cover, and slips of glass being laid around three of the sides, the mercury is poured on till it covers the foil to the depth of about ¼ of an inch. Its affinity for the tin, and the slips of glass, prevent its flowing off. The glass plate rendered perfectly clean is then slidden along the open side, the advancing edge being kept in the mercury, so that no air nor oxide of the metal can get between the plate and the amalgam. The plate, when in place, is secured and pressed down by weights laid upon it, and the table is raised a little to allow the excess of mercury to trickle off by the grooves and collect in a vessel placed on the floor to receive it. After remaining thus for several hours, the plate is taken off and turned over upon a frame. After several weeks the amalgam becomes hard, and the glass may then be set on edge.

Amalgams of the precious metals are used for what are called the water-gilding and water-silvering methods of gilding and silvering applied to buttons and various other metallic articles. These, being made chemically clean, are washed over with the amalgam contained in a large excess of mercury, and are then placed in a furnace and heated till the mercury is driven off by the heat, leaving a thin film of the precious metal, which may then be burnished.

Mercurial medicines, as calomel, (the chloride,) and blue mass, which is the metal reduced to fine particles by long-continued trituration, and incorporated with twice its weight of confection of roses and liquorice root, are very largely prepared, especially for the southern and western states and the West India islands. The labor of triturating the mercury for blue mass has led to the introduction of ingenious machinery for the purpose, invented by Mr. J. W. W. Gordon of Baltimore, and by Dr. E. R. Squibb of Brooklyn, and worked by the latter at his pharmaceutical laboratory by steam power.

CHAPTER VIII.

SILVER—COBALT—NICKEL—CHROME—MANGANESE—TIN.

But few other ores of much importance are found in the United States, besides those of which accounts have been given; and it remains to describe the occurrence and applications of the ores of those metals only which are comprised in the heading of this chapter.

SILVER.

The occurrence of this metal in the United States is chiefly limited to some of the lead ores; and in very few of these, as noted in the chapter upon lead, has it been found in sufficient quantity to justify the working of the mines and separation of the silver. The Washington mine in Davidson co., N. C., is still worked with moderate success for both metals; but the only promising silver mines are those of Arizona, near the Gila river in New Mexico, and the Washoe mines on the extreme western verge of the Utah territory.

In the territory of Arizona, especially in that portion of it ceded to the United States under the Gadsden treaty, are numerous mines productive in silver, some of which were worked when the territory belonged to old Spain. These are now attracting the attention of Americans, and in 1859 and 1860, companies were organized in Cincinnati, New York, and St. Louis, for exploring and working them. The principal mine is that of the Sonora Company, of Cincinnati. The locality is about 75 miles south of Tucson, and about 270 miles north of Guaymas, which is the chief port of the Gulf of California. Several mines in the vicinity were formerly worked by the Mexicans for silver, and abandoned in consequence of Indian depredations and political troubles. The Sonora Company commenced operations in 1858 upon a new discovery, and have produced a considerable amount of silver, reduced from the ores at their works, at Arivaca, 7 miles from the

mines. Seventy miles north of Tucson, operations were commenced in 1860, in another locality, on the same mining range, by a company organized in New York, called the Maricopa Mining Company. Their mine affords rich argentiferous copper ores, samples of which have been brought to New York, and assayed by Prof. John Torrey, and other chemists. They proved to be vitreous copper, associated with carbonates, and yielded an average of over 50 per cent. of copper. The metal contained variable amounts of silver, worth from $40 to $80 per ton. Gold was also detected in it. The outlet for this is also by Guaymas, 420 miles distant, through a region easily traversed by wagons, and upon long-established routes. The cost of transportation, by contracts of Mexicans, is at the rate of 5¼ cents per lb., for the whole distance. In the vicinity of the mines, on the Gila river, it is proposed to reduce the ores. The region is on the Pacific slope of the range of the silver mining districts of Sonora and Durango, and its rock formations are granitic and metamorphic, traversed by dikes of trap, and containing beds of quartz.

On the Rio Mimbres, 240 miles east of Tucson, are the Santa Rita del Cobre and Mimbres mines, from which 333,000 lbs. of copper are reported as having been delivered in New York in 1860. The metal was smelted at the mines, transported through Texas to Port Lavacca, and thence to New York. Whether the ores contain silver or not, is not known. Besides the operations above named, others are in progress in Arizona, of which we have no details. The region is described in the "Personal Narrative" of J. R. Bartlett, Esq., and in the Congressional Pacific Railroad reports.

The Washoe ores are argentiferous galenas of richness varying between great extremes, some of the best sorts which have been shipped to New York, and thence to England, containing enough silver to give them a value of $2000 per ton. The mines are in the inferior range of hills along the eastern base of the Sierra Nevada, and are met with over an extensive territory in the valley of the upper portion of Carson's River and many miles beyond this to the north. Those of most importance are in the vicinity of several new towns, called Virginia City, Silver City, Carson City, etc., about 160 miles north-east from Sacramento. From that point the crest of the Sierra Nevada is reached in 100 miles, nearly due east, and the remaining 60 miles is down the valley of Carson's River. The discoveries of the silver ores were made the latter part of the year 1859, but it was known before this that gold existed in the valley, and that the value of this metal was deteriorated by the silver with which it was usually alloyed. The opening of permanent veins of silver ores produced a great excitement throughout California, and led to an extraordinary emigration to the new mining district, and rapid development during the year 1860 of its resources. The considerable number of mines already in operation, upon veins of unquestionable permanency, and the great richness of some of the ores, together with the variety of those already found, leave no room for doubting that this is a mining region of great importance, and must largely add to the metallic productions of the extreme western states.

The ores, on account of their complex character, are difficult to reduce with economy, and the ordinary methods of obtaining the lead fail, when applied to compounds like these, which contain a large proportion of silica, from which the galena cannot be mechanically separated. The German method of treating such ores, employed at Clausthal, is to reduce them in small blast furnaces, with a flux of granulated cast iron, or of iron turnings, admitting only air enough to keep up the combustion of the fuel. The lead and silver are set free by the sulphur of the ore combining with the iron, and the formation of infusible silicates of oxide of lead is prevented by guarding against the oxidation of lead, through too great access of air. The separation is, however, very imperfect in a single operation, and the rich slags obtained are roasted in order to convert the sulphuret of iron into oxide of iron, which, combining with the silicates of the scoriæ, forms very fusible compounds, which are then returned to the furnace mixed with fresh charges of ore. The silver goes with the lead, and is separated by cupellation.

COBALT.

The ores of this metal are of rather rare occurrence, and are applied to practical purposes not to furnish the metal but its oxide, which is of value for its property of giving a beautiful blue color to glass with which it is melted, and of producing other fine colors when mixed with some other sub-

stances. The ores are sought for all over the world for the supply of the British manufactories of porcelain, stained glass, etc. They are chiefly combinations of cobalt with arsenic, sulphur, and sometimes with nickel and iron. The compound known as smaltine, or arsenical cobalt, was obtained at Chatham, Conn., as far back as 1787, and the mine has been worked for cobalt at different times in the present century. The cobalt in the ore is associated with about an equal amount of nickel, and its proportion is said to have been less than two per cent. Cobaltine, which is a compound of sulphur 19.3 per cent., arsenic 45.2, and cobalt 35.5, is the most productive ore of this metal, but is not met with in this country. Varieties of pyritous cobalt have been found in Maryland in quantities too small for working; and also at Mine la Motte in Missouri, associated with a black earthy oxide of cobalt and black oxide of manganese. In other places, also, oxide of cobalt, in small quantity, is a frequent accompaniment of manganese ores. Mine la Motte has furnished a considerable amount of the cobalt oxide, but the beds in which it is found are not of permanent character, and are so far exhausted as to be no longer worked with profit. A similar ore, accompanied with nickel, appears to be very abundantly distributed among the talcose and quartzose slates in Gaston and Lincoln counties, North Carolina. It is thrown out with a variety of other ores, as galena, blende, titaniferous iron, etc., in working the gold mines of this region; and it is mixed among the great beds of hematite, found in the same district, which are the product of the decomposition of beds of pyritous iron. In some places it is so abundant that the strata containing it are conspicuous where the roads pass over them, by the blackness of the gossan (decomposed ore) or wad. Prof. H. Wurtz, who describes these localities (see "American Journal of Science," 2d series, vol. xxvii., p. 24), is of opinion that the earthy oxide of cobalt is the gossan of the sulphuret of this metal, existing unaltered in the rocks below.

Oxide of cobalt, obtained in a crude state from the washed arsenical ores, is known as zaffre or saflor, and in this condition it is a commercial article. It is refined by separating the arsenic, iron, and other foreign substances, by precipitating them from the solution in hydrochloric acid; and the oxide is finally obtained by precipitating with chloride of lime, and heating the product to redness. Smalt is a preparation of cobalt largely used in the arts as a coloring material, and consists of silicate of potash and cobalt. It is in fact a potash glass colored by silicate of cobalt, and is prepared as follows: Zaffre is melted in pots, with suitable proportions of pure sand and potash and a little saltpetre. The other metals combine together and sink in a metallic mass, which is called speiss. The glass containing the oxide of cobalt is ladled out and poured into water to granulate it, and is then ground to powder. This being introduced into vats of water, the colored glass subsides in deposits, which gradually diminish in their proportions of oxide of cobalt. The first are of the deepest blue, and are called azure; but of this, and of the succeeding fainter shades, there are many varieties, distinguished by peculiar names. When finely powdered, smalt is applied to coloring wall papers, and blueing linen, besides being incorporated with porcelain to impart to it permanent blue shades. The great value of oxide of cobalt, amounting to several dollars per lb., renders it an important object to fully develop the resources of the country in its ores, as well for export as for domestic use. In 1856 there were imported into Great Britain 428 tons of cobalt ore, and 34 tons of oxide of cobalt.

NICKEL.

Nickel is a metal of some commercial importance, and is employed chiefly for producing, with copper and zinc, the alloy known as German silver. The proportions of these metals are not constant, but the most common in use are eight parts of copper to three each of nickel and zinc. The larger the proportion of copper, the more easily the plates are rolled; but if more is used than the relative amounts named, the copper soon becomes apparent in use. The new cent contains 12 parts of nickel to 88 of copper, and the manufacture of this adds somewhat to the demand. The metal has been mined at Chatham, Conn., and is met with at Mine la Motte and other localities where cobalt is found. It occurs in greatest abundance at an old mine in Lancaster county, Penn., where it is associated with copper ores. The mine was originally worked for copper, it is said, more than one hundred and thirty years ago, and was reopened for supplying nickel for the U. S. Mint, on the introduction of

the new cent in 1857. The sulphuret of nickel, containing, when pure, 64.9 per cent. of nickel, and 35.1 per cent. of sulphur, is in very large quantity, in two veins of great size, one of which has been traced over 600 feet, and the other over 900 feet in length. In 1859 it was producing at the rate of 200 tons of nickel ore and ten tons of copper ore per month. A pyritous variety of nickel ore, called siegenite, is found at Mine la Motte, Missouri, and in Carroll county, Maryland. In Gaston and Lincoln counties, North Carolina, similar ore was found by Prof. Wurtz, as noticed in the remarks on cobalt, above.

CHROME OR CHROMIUM.

The ore of this metal, known as chromic iron or chromate of iron, has been mined for many years in the United States, both for exportation and domestic use. It is the source whence the chrome colors are obtained that are largely used in the arts, especially in dyeing and calico printing. The name of the metal, from a Greek word meaning color, was given in consequence of the fine colors of its compounds. It usually consists of the sesquioxide of chromium in proportion varying from 36 to 60 per cent., protoxide of iron from 20 to 37 per cent., alumina sometimes exceeding 20 per cent., and more or less silica, and sometimes magnesia. Its value consists only in the first-named ingredient. The localities of the ore are in the serpentine rocks of different parts of the United States, as in the Bare Hills, near Baltimore, and near the Maryland state line on the southern edge of Chester and Lancaster counties, Pennsylvania. In small quantities the ore is met with at Hoboken, Staten Island, and other places near New York city. It is found in several towns in Vermont, but the largest veins of it are in Jay, in the northern part of the state. The composition of this ore was found by Mr. T. S. Hunt to be 49.9 of green oxide or sesquioxide of chromium, 48.96 of protoxide of iron, and 4.14 per cent. of alumina, silica, and magnesia. Though the quantity of the ore in this region is reported to be large, the principal supplies of the country have been obtained in Maryland, and from the mines just over the state line in Pennsylvania. The ore, as recently as 1854, was found in loose fragments among the disintegrated materials of the serpentine upon the tracts called the barrens, and was gathered up from the valleys and ravines, and dug out in sinking shallow pits and trenches over the surface. The ore thus obtained was called "sand chrome," and for a time it had been worth $45 per ton, and thousands of tons had been collected and shipped, principally to Baltimore. At the period named these superficial deposits were mostly exhausted, and the value of the ore was only about $25 per ton. This, however, was sufficient to sustain regular mining operations, which were then carried on upon the veins found in the serpentine, a little west of the east branch of the Octorara Creek. Wood's chrome mine, near the Horse-shoe Ford, was at that time about 150 feet deep, and the workings had been extended north-east and south-west about 300 feet, upon an irregular vein of chrome ore, which lay at an inclination of about 45° with the horizon toward the north-west. The ore, in places, formed bunches, which attained a width of 20 feet, and then thinned away to nothing. Four men obtained from the mine 7 or 8 tons of excellent ore a day, the best of which was directly placed in barrels for the foreign market, and the poorer was dressed and washed for the Baltimore, and other home markets. The state line mine, in the same vicinity, worked to about the same depth, had produced several thousand tons. The supplies of this ore are always of uncertain continuance.

Useful Applications. — Chromate of iron is used chiefly in the production of chromate of potash, and from this the other useful chromatic salts are obtained. The object in view in the chemical treatment of the ore is to convert the sesquioxide of chromium into the peroxide or chromic acid, and cause this to combine with potash. This may be effected by various methods, as by exposing a mixture of the pulverized ore and of saltpetre (nitrate of potash) to a strong heat for some hours. The chrome is peroxidized at the expense of the oxygen of the nitric acid of the saltpetre, and the chromic acid combines with the potash; or if the ore is mixed with carbonate of potash and calcined, the peroxidation of the chrome is effected by admission of air into the furnace, and the same product is obtained as in the employment of saltpetre. The introduction of lime hastens the operation. Other mixtures also are used for the same purpose. When the calcined matter, having been drawn out from

the furnace, is lixiviated with water, the chromate of potash is dissolved and washed out, and is afterward recovered in the form of yellow crystals on evaporating the water. From chromate of potash the other salts are readily produced. Chrome yellow, used as a paint, is prepared by mixing chromate of potash with a soluble salt of lead, and collecting the yellow precipitate of chromate of lead which falls. A bright red precipitate is obtained by thus employing a salt of mercury, and a deep red with salts of silver. Chrome green is produced by mixing Prussian blue with chrome yellow. Some new and very interesting compounds of the sesquioxide of chromium with different bases have been recently obtained by Prof. A. K. Eaton of New York, and in consequence of their decided colors and the extraordinary permanency of these against powerful reagents applied to remove them, the salts were employed for printing bank-notes. Though they proved to be all that was required as to the colors themselves, the steel plates were so rapidly cut by the excessively sharp and hard powders, however finely they were ground, that it was found necessary to abandon their use. The new salts were chromites—that of iron having a dark purple color; of manganese, a lighter shade of the same; of copper, a rich blueish black; of zinc, a golden brown; of alumina, a green, somewhat paler than that of the sesquioxide.

MANGANESE.

Though this is a metal of no value of itself, one of its ores, called pyrolusite, is a mineral of some commercial importance, chiefly on account of the large proportion of oxygen it contains, part of which it can be easily made to give up when simply heated in an iron retort. The composition of pyrolusite, or black oxide of manganese, is 63.4 per cent. of manganese, and 36.6 per cent. of oxygen. It is a hard, steel-gray ore, resembling some of the magnetic iron ores, and is often found accompanying iron ores, especially the hematites. In the United States it is met with in various localities along the range of the hematites, from Canada to Alabama, and has been mined to considerable extent at Chittenden and Bennington, Vermont; West Stockbridge and Sheffield, Mass.; on the Delaware river, and near Kutztown, Berks co., Penn.; and abounds in different parts of the gold region, as on Hard-labor Creek, Edgefield District, S. C. Usually the ore is found in loose pieces among the clays which fill the irregular cavities between the limestone strata; its quantity is of course very uncertain, and its mines are far from being of a permanent character. Oxide of iron is commonly mixed with the manganese ore, reducing its richness, and at the same time seriously injuring it for some of the purposes to which it is applied. As obtained from the mines, the assorted ore is packed in barrels and sent to the chemical establishments, where it is employed principally in the manufacture of chloride of lime or bleaching powder. For this purpose the pulverized black oxide of manganese is introduced into hydrochloric acid, and this being heated a double decomposition takes place, a portion of its chlorine is expelled, and the hydrogen that was combined with it unites with a part of the oxygen of the pyrolusite. The chlorine, which it was the object of the process to obtain, is then brought in contact with hydrate of lime, and uniting with the calcium base, forms the bleaching powder. A similar result is obtained by mixing the oxide of manganese with chloride of sodium (common salt), and adding sulphuric acid. By these operations a weight of oxygen equal to about one third that of the pure ore may be obtained, and this may be applied to any of the purposes for which oxygen not absolutely pure is required. Black oxide of manganese is also used to decolorize glass stained green by the presence of the protoxide of iron. Its own amethystine tint is supposed to neutralize the optical effect of the greenish hue of the iron. The market for manganese ore is as uncertain as the supply, and the price varies greatly with the quality of the ore. Pure pyrolusite, free from iron, might be shipped to profit to Liverpool, where it is worth $35 to $40 per ton, but inferior ore would involve bills of cost.

TIN.

The very useful metal, tin, is not one of the products of this country, and there is no encouragement for hoping that its ores will ever be found in workable quantity. Its presence has been recognized in a few small crystals of oxide of tin, found in Chesterfield and Goshen, Mass., and it has been detected as a mere trace in the iron ores of the Hudson, and iron and zinc ores of New Jersey; it is also associated with some of

the gold ores of Virginia. In the town of Jackson, N. H., is a vein of arsenical iron, containing thin streaks of oxide of tin; and this is the only place that has afforded enough of the ore for crucible experiments. The commercial supplies are furnished chiefly from the mines of Cornwall, England, and from Banca, and other islands of the Malay archipelago. The United States is one of the largest consumers of tin of any nation, sheet tin having been applied, through the industry and ingenuity of the workers of this article in Connecticut, to the manufacture of a great variety of useful utensils, which have been widely distributed throughout the states. What is called sheet tin is really sheet iron coated with a very thin layer of tin. The sheets are prepared in England by dipping the brightened iron sheets into a bath of melted tin. The process has been applied to coating various articles made of iron, which are thus protected from rusting; and zinc is also used for similar purposes. Such are stirrups, bridle-bits, etc. Cast-iron pots and saucepans are tinned on the inside by melted tin being poured in and made to flow over the surface, which has been made chemically clean to receive the metal. The surface is then rubbed with cloth or tow. Tin is imported in blocks or ingots, and the metal is applied to the preparation of various alloys, as bronze or bell-metal, composed of copper and tin in variable proportions, commonly of 78 parts of copper, and 22 of tin; gun-metal, copper 90, and tin 10; pewter, of various proportions of tin and lead, or when designed for pewter plates, of tin 100, antimony 8, bismuth 2, and copper 2; and soft solder, consisting of tin and lead, usually of two parts of the former to one of the latter. Bismuth is sometimes added to increase the fusibility of the alloy.

CHAPTER IX.

COAL.

To the early settlers of the American colonies the beds of mineral coal they met with were of no interest. In the abundance of the forests around them, and with no manufacturing operations that involved large consumption of fuel, they attached no value to the black stony coal, the real importance of which was not in fact appreciated even in Europe until after the invention of the steam engine. The earliest use of mineral coal was probably of the anthracite of the Lehigh region, though it may be that the James River bituminous coal mines, 12 miles above Richmond, were worked at an earlier period than the Pennsylvania anthracites. The region containing the latter belonged to the tribes of the Six Nations, until their title was extinguished and the proprietary government obtained possession, in 1749, of a territory of 3750 square miles, including the southern and middle of the three anthracite coal-fields. In 1768 possession was acquired of the northern coal-field, and at the same time of the great bituminous region west of the Alleghany mountains. The existence of coal in the anthracite region could not have escaped the notice of the whites who had explored the country, for its great beds were exposed in many of the natural sections of the river banks and precipitous hills, and down the mountain streams pieces of coal, washed out from the beds, were abundantly scattered. The oldest maps now known, dating as far back as 1770, and compiled from still older ones, designate in this region localities of "coal;" but these were probably not regarded as giving any additional value to the territory. The first recorded notice of its use was in the northern basin by some blacksmiths in 1770, only two years after the whites came in possession; and in 1775 a boat load of it was sent down from Wilkesbarre to the Continental armory at Carlisle. This was two years after the laying out of the borough of Wilkesbarre by the Susquehanna Land Company of Connecticut. From this time the coal continued to be used for mechanical operations by smiths, distillers, etc.; and according to numerous certificates from these, published in 1815, in a pamphlet by Mr. Zachariah Cist of Wilkesbarre, they had found it very much better for their purposes, and more economical to use than Virginia bituminous coal, though at the enormous price of 90 cents a bushel. Gunsmiths found it very convenient for their small fires, and one of them, dating his certificate December 9, 1814, stated that he had used it for 20 years, consuming about a peck a day to a fire, which was sufficient for manufacturing 8 musket-barrels, each barrel thus requiring a quart of coal. Oliver Evans, the inventor of the steam engine, certifies in the same pamphlet to his having used it for raising steam, for

which it possessed properties superior to those of any other fuel. Judge Fell of Wilkesbarre applied it to warming houses in 1808, and contrived suitable grates for this use of it; but the cheapness of wood and the greater convenience of a fuel which every one understood how to use, long prevented its general adoption. In the first volume of the "Memoirs of the Historical Society of Pennsylvania," T. C. James, M.D., gives "a brief account of the discovery of anthracite coal on the Lehigh," in which he describes a visit he made to the Mauch Chunk mountain in 1804, where he saw the immense body of anthracite, into which several small pits had then been sunk, and which was afterward worked, as it is still, as an open quarry. He states that he commenced to burn the coal that year, and had continued to use it to the time of making this communication in 1826. The discovery of this famous mass of coal was made in 1791, and in 1793 the "Lehigh Coal Mine Company" was formed to work it. But as there were no facilities for transporting the coal down the valley of the Lehigh, nothing was done until 1814, when, at great labor and expense, 20 tons were got down the river and were delivered in Philadelphia. Two years before this a few wagon loads had been received there from the Schuylkill mines; but the regular trade can hardly be said to have commenced until 1820, when the receipts in Philadelphia amounted to 365 tons. Such was the commencement of the great anthracite trade of Pennsylvania, which in the course of 40 years has been steadily increasing, till it now reaches the enormous amount of 8,450,053 tons for the year 1860, and sustains numerous branches of metallurgical and mechanical industry, the possible dependence of which upon this fuel and source of power was hardly dreamed of when its mines were first opened.

The existence of bituminous coal west of the Alleghanies was probably known as early as was that of anthracite in the eastern part of Pennsylvania; and on the western rivers it could not fail to have been noticed by the early missionaries, voyageurs, and hunters. In the old maps of 1770 and 1777 the occurrence of coal is noted at several points on the Ohio. A tract of coal land was taken up in 1785 near the present town of Clearfield, on the head-waters of the west branch of the Susquehanna, by Mr. S. Boyd, and in 1804 he sent an ark load of the coal down the Susquehanna to Columbia, Lancaster county, which, he states, caused much surprise to the inhabitants, that "an article with which they were wholly unacquainted should be thus brought to their own doors." This was the commencement of a trade which has since been prosecuted to some extent by running rafts of timber loaded with coal, and sometimes with pig iron also, from the head-waters to the lower portion of the Susquehanna. The bituminous coal mines on the James River, 12 miles above Richmond, in Virginia, were also worked during the last century, but at how early a period we are ignorant. In an account of them in the first volume of the "American Journal of Science," published in 1818, they are spoken of as already having been worked 30 years.

VARIETIES OF COAL.

The mineral coals are found of various sorts, which are distinguished by peculiarities of appearance, composition, and properties. Derived from vegetable matters, they exhibit in their varieties the successive changes which these have undergone from the condition of peaty beds or deposits of ligneous materials—first into the variety known as brown coal or lignite, in which the bituminous property appears, while the fibre and structure of the original woody masses is fully retained; next in beds of bituminous coal comprised between strata of shales, fire-clay, and sandstones; and thence through several gradations of diminishing proportions of bitumen to the hard stony anthracite, the composition of which is nearly pure carbon; and last of all in this series of steps attending the conversion of wood into rock, the vegetable carbon is locked up in the mineral graphite or plumbago. These steps are clearly traceable in nature, and in all of them the strata which include the carbonaceous beds have undergone corresponding changes. The clayey substratum that supports the peat appears under the beds of mineral coal in the stony material called fire-clay (used when ground to make fire-brick); the muddy sediments such as are found over some of the great modern peat deposits, appear in the form of black shales or slates, which when pulverized return to their muddy consistency; the beds of sand, such as are met with in some of the peat districts of Europe interstratified with different peat beds, are seen in the coal-measures in beds of sandstones; and the limestones which also

occur in the same group of strata, represent ancient beds of calcareous marls. The slow progression of these changes is indicated by the different ages of the geological formations in which the several varieties occur. Beds of peat are of recent formation, though some of them are still so old, that they are found at different depths, one below another, separated by intervening layers of sand, clay, and earth. Brown coal, or lignite, is commonly included among the strata of the tertiary period; the bituminous coals are in the secondary formations; and the anthracites, though contained in the same geological group with the great bituminous coal formation, are in localities where the strata have all been subjected to the action of powerful agents which have more or less metamorphosed them and expelled the volatile bitumen from the coal. The graphite or plumbago is in still older groups, or in those which have been still more metamorphosed by heat.

All these varieties of fossil fuel are found in the United States. Peat beds of small extent are common in the northern portion of the country, and in some parts of New England are much used for fuel, and the muck, or decomposed peat, as a fertilizer to the soil. In the great swamps of southern Virginia, the Carolinas, and Georgia, vegetable deposits of similar nature are found upon a scale more commensurate with the extent of the ancient coal-beds. Lignite is not found in workable beds, as in some parts of Germany and England, but in scattered deposits of small extent among the tertiary clays, chiefly near the coast of New Jersey, Delaware, and Maryland, and in the western territories. The distribution of the true coal formations will be pointed out after designating more particularly the characters of the different coals All of these consist of the elements carbon, hydrogen, oxygen, and nitrogen; the carbon being in part free, and in part combined with the other elements to form the volatile compounds that exist to some extent in all coals. Earthy matters which form the ash of coals are always intermixed in some proportion with the combustible ingredients, and water, also, is present. When coals are analyzed for the purpose of indicating their heating quality by their composition, it is enough to determine the proportions of fixed carbon, of volatile matter, and of ash which they contain. How the combined carbon, hydrogen, oxygen, and the little nitrogen in their composition, may be distributed in the forms of carburetted hydrogen, ammonia, the bituminous oils, etc., cannot be ascertained by analysis, as the means employed to separate most of these compounds cause their elements to form other combinations among themselves: the determination of the ultimate proportions of all the elements would serve no practical purpose. So, if it be required to prove the fitness of any coal for affording illuminating gas, or the coal oils, it must be submitted to experiments having such objects only in view; and even their capacity for generating heat is better determined by comparative experiments in evaporating water, than by any other mode. The bituminous coals are characterized by their large proportion of volatile matter, which, when they are heated, is expelled in various inflammable compounds, that take fire and burn, accompanied by a dense, black smoke and a peculiar odor known as bituminous. If the operation is conducted without access of air, as in a closed platinum crucible, the fixed carbon remains behind in the form of coke; and by removing the cover to admit air, this may next be consumed, and the residuum of ash be obtained. By several weighings the proportions are indicated. Coals containing 18 per cent. or more of volatile matter are classed among the bituminous varieties; but as the proportion of this may amount to 70 per cent. or more, there is necessarily a considerable difference in the characters of these coals, though their most marked peculiarities are not always owing to the different amounts of volatile matter they contain. Thus, some sorts, called the "fat bituminous," and "caking coals," that melt and run together in burning, and are especially suitable for making coke, contain about the same proportion of volatile matter with the "dry coals," as some of the cannel and other varieties, which burn without melting, and do not make good coke. Other varieties are especially distinguished for their large proportion of volatile ingredients; such are the best cannels, and those light coals which have sometimes been mistaken for asphaltum, as the Albert coal of the province of New Brunswick. These varieties are eminently qualified for producing gas or the coal oils; but have little fixed carbon, and consequently can produce little coke. Coals that contain from 11 to 18 per cent. volatile matter, are known as semi-bi-

tuminous, and partake both of the qualities of the true bituminous coals, in igniting and burning freely, and of the anthracite in the condensed and long-continued heat they produce. The Maryland coals, and the Lykens valley coal of Pennsylvania, are of this character. The true anthracites contain from 2 to 6 per cent. of gaseous matters, which by heat are evolved in carburetted hydrogen and water, even when the coal has been first freed from the water mechanically held. Their greatest proportion of solid carbon is about 95 per cent. There remains a class which has been designated as semi-anthracite, containing from 6 to 11 per cent. of combustible volatile matter. These coals burn with a yellowish flame, until the gas derived from the combination of its elements is consumed.

The earthy ingredients in coals, forming their ash, are derived from the original wood and from foreign substances introduced among the collections of ligneous matters that make up the coal-beds. The ash is unimportant, excepting as the material which produces it takes the place of so much combustible matter. In some coals, especially those of the Schuylkill region, it is red, from the presence of oxide of iron, and in others it is gray, as in the Lehigh coals. This distinction is used to designate some of the varieties of anthracite; but the quality of these coals is more dependent on the quantity of the ash, than on its color. From numerous analyses of the Schuylkill red ash coals an average of 7.29 per cent. of ash was obtained, and of the white ash anthracite, 4.62 per cent. Coals producing red ash are more likely to clinker in burning than those containing an equal amount of white ash. In some varieties of coal the proportion of earthy matter is so great that the substance approaches the character of the bituminous shales, and may be called indifferently either shale or coal. Though such materials make but poor fuel, some of them have proved very valuable from the large amount of gas and of oily matters they afford. The most remarkable of this class is that known as the Boghead cannel. This is largely mined near Glasgow, in Scotland, and is imported into New York to be used in the manufacture of coal oil. It is a dull black, stony-looking substance, having little resemblance to the ordinary kinds of coal. Its composition is given for comparison with that of other coals, in the following table:—

	Localities.	Authority.	Specific Gravity.	Carbon.	Water and other Vol. Mat.	Ashes.
ANTHRACITE. WHITE ASH. RED ASH.	Shenowith Vein, Penn	H. D. Rogers	1.50	94.10	1.40	4.50
	Peach Mountain, Penn.; mean of 40 analyses	W. R. Johnson	1.46	86.09	6.96	6.95
ANTHRACITE. WHITE ASH.	Lackawanna	W. R. Johnson	1.42	88.98	6.36	4.66
	Beaver Meadow	"	1.56	91.64	6.89	1.47
	Price's Mountain, Montgomery Co., Virginia	A. H. Everett	1.37	89.25	2.44	8.30
	Portsmouth, Rhode Island	Dr. C. T. Jackson	1.85	85.84	10.50	3.66
	Mansfield, Mass	"	1.69	87.40	6.20	6.40
SEMI-BITUMINOUS.	Atkinson's and Templeman's, Maryland; average of 2 specimens	W. R. Johnson	1.313	76.69	15.53	7.83
	George's Creek, Maryland	"	1.35	70.75	16.03	13.22
BITUMINOUS.	Pittsburg, Pennsylvania	B. Silliman, jr.	..	64.72	32.95	2.31
	Cannelton, Indiana	W. R. Johnson	1.272	59.47	36.59	3.94
	Black Heath, James River, Virginia	"	..	58.79	32.57	8.64
	Monroe Co., S. Illinois	J. G. Norwood	1.246	58.70	36.20	4.50
	La Salle Co., N. Illinois	"	1.237	55.10	39.90	3.00
	Albert Coal, New Brunswick	B. Silliman, jr.	1.129	36.04	61.74	2.22
	Grayson (Ky.) cannel	"	1.371	14.36	62.03	23.62
	Breckenridge (Ky.) cannel	"	1.150	27.16	64.30	8.48
	Boghead, black cannel	Dr. Penny	1.218	9.25	62.70	26.50
	Boghead, brown	"	1.160	7.10	71.06	20.20

A complete description of the coals, such as may be found in the Report of Prof. Walter R. Johnson (Senate Document, 28th Congress, No. 386), and presented, in a condensed form, in Johnson's Edition of "Knapp's Chemical Technology," presents many other features affecting the qualities of the coals, and their adaptation to special uses. Such are—1, their capacity for raising steam quickly; 2, for raising it abundantly for the quantity used; 3, freedom from dense smoke in their combustion; 4, freedom from tendency to crumble in handling; 5, capacity, by reason of their density, and the shapes assumed by their fragments, of close stowage; and 6, freedom from sulphur. The last is an important consideration, affecting the value of coals proposed for use in the

iron manufacture, sulphur, which is often present in coal in the form of sulphuret of iron, having a very injurious effect upon the iron with which it is brought in contact when heated. It is again to be cautiously guarded against in selecting bituminous coals to be employed in steam navigation; for by the heat generated by spontaneous decomposition of the iron pyrites, the easily ignited bituminous coals may be readily set on fire. This phenomenon is of frequent occurrence in the waste heaps about coal mines, and large bodies of coal stored in yards and on board ships have been thus inflamed, involving the most disastrous consequences. In stowage capacity coals differ greatly, and this should be attended to in selecting them for use in long voyages. Tendency to crumble involves waste. Dense smoke in consuming is objectionable in coals required for vessels-of-war in actual service, as it must expose their position when it may be important to conceal it. The following table was prepared by Prof. Johnson to present some of the general results in these particulars of his experiments:—

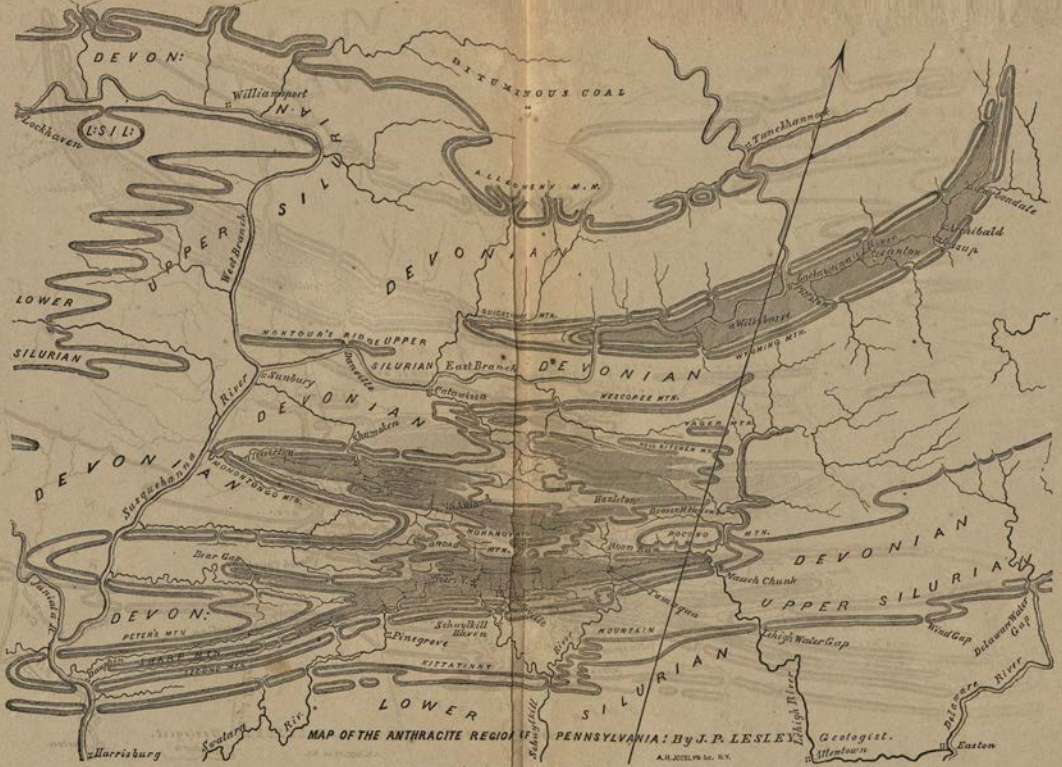
GENERAL SCALE OF RELATIVE VALUES FORMED FROM THE AVERAGES OF EACH CLASS OF COAL SUBJECTED TO TRIAL.

	1.	2.	3.	4.	5.
Maryland free-burning coals	1000	1000	395	880	682
Pennsylvania anthracite	977	986	1000	893	319
Pennsylvania bituminous	951	938	390	1000	914
Virginia (James River) bituminous	850	757	242	948	730
Foreign bituminous	801	741	331	948	1000

Column 1 gives the relative evaporative powers of equal weights of the coals; 2, the same of equal bulks; 3, their relative freedom from tendency to clinker; 4, rapidity of action in evaporating water; 5, facility of ignition, or readiness with which steam is gotten up. The general results of experience in use, as well as of special trials systematically conducted upon a large scale, agree in these particulars—that while the bituminous coals are valuable for the greater variety of uses to which they are applicable, and especially for all purposes requiring flame and a diffusive heat, as under large boilers; and while they are quickly brought into a state of combustion, rendering the heat they produce more readily available; the anthracites afford a more condensed and lasting heat, and are to be preferred in many metallurgical operations, especially where great intensity of temperature is required. And for many purposes, the free-burning, semi-bituminous coals, which combine the useful properties of both varieties, are found most economical in use.

GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION.

The United States is supplied with coal from a number of coal-fields belonging to what are called the true coal-measures, or the carboniferous group, a series of strata sometimes amounting, in aggregate thickness, to 2000 and even 3000 feet, and whether found in this country or in Europe, readily recognized by the resemblance in the various members of its formation, its fossil organic remains, its mineral accompaniments, and by its position relative to the other groups of rock which overlie and underlie it. The principal one of these fields or basins is that known as the Appalachian, which, commencing in the north-eastern part of Pennsylvania, stretches over nearly all the state west of the main Alleghany ridge, and takes in the eastern portion of Ohio, parts of Maryland, Virginia, Kentucky, Tennessee, the north-west corner of Georgia, and extends into Alabama as far as Tuscaloosa. Its total area, including a number of neighboring basins, as those of the anthracite region to the east of the Alleghany ridge, which were originally a part of the same great field, is estimated at about 70,000 square miles. A second great basin is that which includes the larger part of Illinois, and the western portion of Indiana and of Kentucky. Its area is estimated at about 50,000 square miles; but its coal-beds are few and thin compared with those of the great Appalachian coal-field. The same may be said of the third coal-field, on the other side of the Mississippi. This extends over a large part of Iowa and of Missouri, and to the Red River in the western part of Arkansas. The Kansas coal-beds are contained in this field, which along its western borders is more or less broken up at the surface by patches of rock of later formation, as the cretaceous and middle secondary. Beneath these groups, the coal-bearing strata disappear toward the great plains. The



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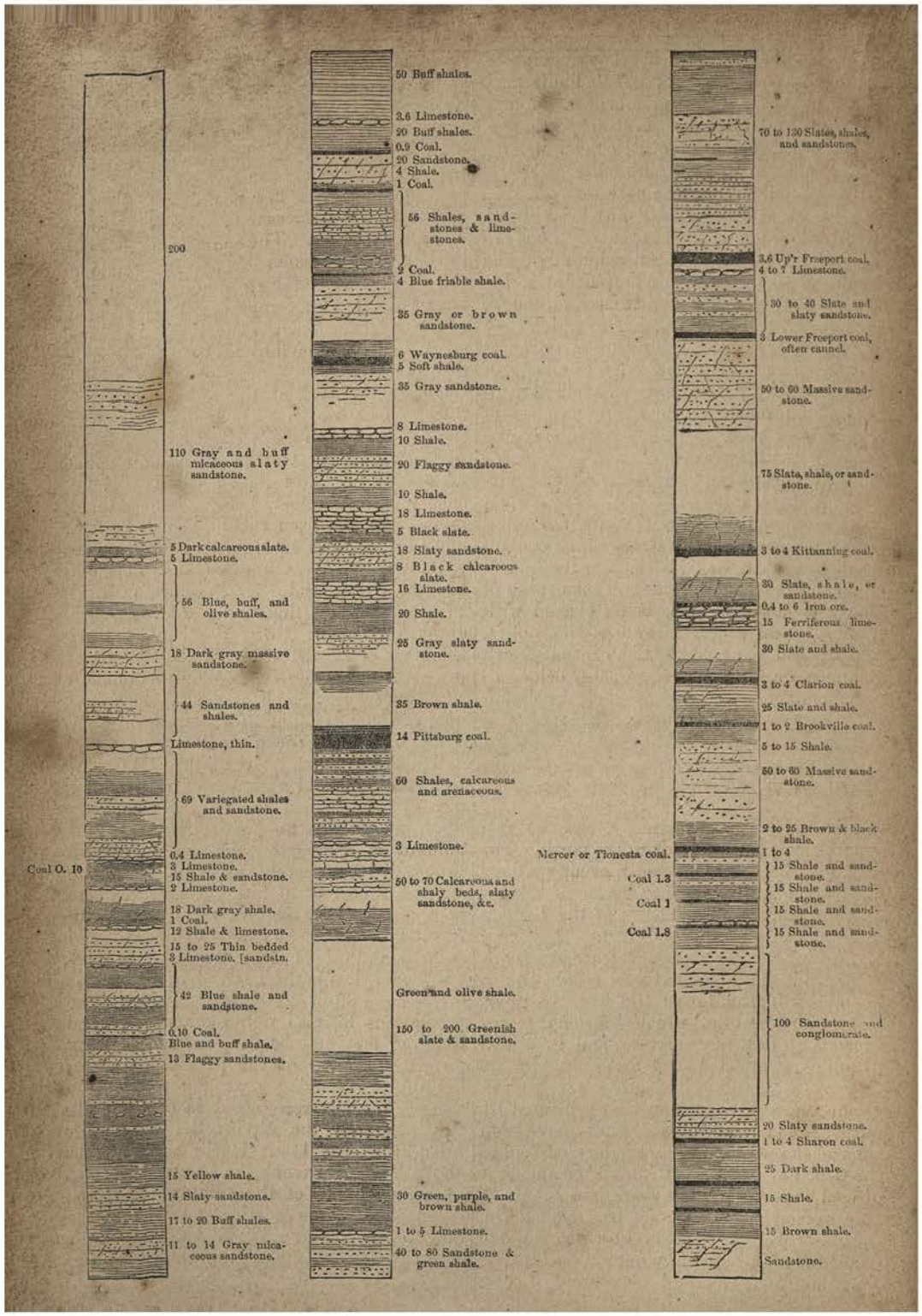
whole area of this field has been computed at 57,000 square miles; but its limits have never been accurately defined. A fourth coal-field occupies the central portion of the southern peninsula of Michigan, its area being about 13,350 square miles. Several small beds of bituminous coal are worked in this district, but they have only local importance. A fifth coal-field is that of Rhode Island and south-eastern Massachusetts. The strata of this district are considered as belonging to the true coal-measures, although, from the metamorphic action to which they have been subjected, their true character is very obscure. They contain a few beds of anthracite, very irregular in their dimensions, and much crushed. A number of mines have been opened, but the only one now worked is at Portsmouth, 8 miles north of Newport. In south-eastern Virginia is a bituminous coal-field, lying on both sides of the James River, a few miles above Richmond. The strata which contain the coal-beds of this district are recognized as members of later formation than those of the true coal-measures, being classed with the geological group known as the oolite, or lias; and the coal-beds of central North Carolina, on Deep River, probably belong to the same position in the geological column. Notwithstanding the limited area of this coal-field in Virginia, which is only about 25 miles long and 8 to 10 miles wide, it has produced for more than sixty years past large quantities of coal chiefly for the supply of iron manufacturing establishments, and the gas-works along the seaboard to the north. The strata of these coal-measures occupy a deep depression in the granitic rocks of this region, attaining in the centre of the basin a thickness of nearly 2000 feet. They consist in great part of a micaceous sandstone, and the two or three coal-beds are contained in the lower 150 feet. A great bed at the bottom, which in some places exceeds 40 feet in thickness, and in others dwindles away to 4 or 5 feet only, appears to have been deposited upon the uneven granitic floor, from which it is separated by only a few inches of slate. Shafts have been sunk near the east border of the coal-field to the depth of nearly 900 feet. The amount of coal obtained of late years does not probably exceed 130,000 tons per annum. A singular phenomenon is observed at one point in this district, where a coal-bed is penetrated and overlaid by a body of trap-rock. The coal near this rock is converted into a mass of coke, resembling that artificially produced, except that it is more compact and of a duller lustre.

A large amount of bituminous coal has been brought to Boston and New York, for many years past, from a coal-field belonging to the true coal-measures, in Nova Scotia and Cape Breton. The same formation extends into New Brunswick, and ranges along the western part of Newfoundland, and has been estimated as comprising in all an area of 9000 square miles. The productive portions, however, are limited to a few localities upon the coast of Nova Scotia and Cape Breton, and at these, beds of great thickness have been opened, and worked to the depth of from 200 to 450 feet. At the Pictou mines, opposite the southern point of Prince Edward's Island, one bed is 29 feet thick. Another bed, at the Albion mines, 8½ miles from Pictou, affords 24 feet of good coal, and 12 more of inferior quality; and in Sydney, Cape Breton, are beds of 11 feet, 9 feet, and 6 feet, besides at least 11 others of less thickness. At the South Joggins cliffs, in Nova Scotia, the total thickness of all the strata of the coal-measures was found by Mr. Logan to amount to 14,571 feet, very much exceeding the thickness of the formation as observed in other places on the American continent.

The strata which make up the coal formation, the principal varieties of which have already been named, are regularly laid one upon another in no particular order, and amount in aggregate thickness to several thousand feet, rarely exceeding in the United States 3000 feet. Their thickness is ascertained by sections measured at different localities, some giving one part of the column, and others other portions. In western Pennsylvania the nearly horizontal beds of rock are often exposed in the sides of the precipitous hills, so that sections of several hundred feet may be fully made up. Any peculiar member of the pile, as a bed of limestone, occurring near the top of the section, may be recognized in other localities, where by the dip of the strata it is brought to the lower levels, and the hills above it then present the succession of the higher members of the column; or if the layer taken as the starting point be in the one case at the base, it will be found in the direction of the rising of the strata, at higher and higher elevations, and the lower mem-


200
110 Gray and buff micaceous slaty sandstone.
5 Dark calcareous slate.
5 Limestone.
56 Blue, buff, and olive shales.
18 Dark gray massive sandstone.
44 Sandstones and shales.
Limestone, thin.
69 Variegated shales and sandstone.
0.4 Limestone.
Coal 0. 10
3 Limestone.
15 Shale & sandstone.
2 Limestone.
18 Dark gray shale.
1 Coal.
12 Shale & limestone.
15 to 25 Thin bedded
3 Limestone. [sandstn.
42 Blue shale and sandstone.
0.10 Coal.
Blue and buff shale.
13 Flaggy sandstones.
15 Yellow shale.
14 Slaty sandstone.
17 to 20 Buff shales.
11 to 14 Gray micaceous sandstone.
50 Buff shales.
3.6 Limestone.
20 Buff shales.
0.9 Coal.
20 Sandstone.
4 Shale.
1 Coal.
56 Shales, sandstones & limestones.
2 Coal.
4 Blue friable shale.
35 Gray or brown sandstone.
6 Waynesburg coal.
5 Soft shale.
35 Gray sandstone.
8 Limestone.
10 Shale.
20 Flaggy sandstone.
10 Shale.
18 Limestone.
5 Black slate.
18 Slaty sandstone.
8 Black calcareous slate.
16 Limestone.
20 Shale.
25 Gray slaty sandstone.
35 Brown shale.
14 Pittsburg coal.
60 Shales, calcareous and arenaceous.
3 Limestone.
50 to 70 Calcareous and shaly beds, slaty sandstone, &c.
Green and olive shale.
150 to 200 Greenish slate & sandstone.
30 Green, purple, and brown shale.
1 to 5 Limestone.
40 to 80 Sandstone & green shale.
70 to 130 Slates, shales, and sandstones.
3.6 Up'r Freeport coal.
4 to 7 Limestone.
30 to 40 Slate and slaty sandstone.
3 Lower Freeport coal, often cannel.
50 to 60 Massive sandstone.
75 Slate, shale, or sandstone.
3 to 4 Kittanning coal.
30 Slate, shale, or sandstone.
0.4 to 6 Iron ore.
15 Ferriferous limestone.
30 Slate and shale.
3 to 4 Clarion coal.
25 Slate and shale.
1 to 2 Brookville coal.
5 to 15 Shale.
50 to 60 Massive sandstone.
2 to 25 Brown & black shale.
Mercer or Tionesta coal.
1 to 4
Coal 1.3
15 Shale and sandstone.
Coal 1
15 Shale and sandstone.
Coal 1.8
15 Shale and sandstone.
100 Sandstone and conglomerate.
20 Slaty sandstone.
1 to 4 Sharon coal.
25 Dark shale.
15 Shale.
15 Brown shale.
Sandstone.

bers of the column will then be brought into view at the base of the hills. Thus, at Pittsburg, the hills opposite the city afford a section of 300 or 400 feet, and the marked stratum is here the great coal-bed, which up the Alleghany river toward the north rises to higher and higher levels in the hills, and toward the south, up the Monongahela, sinks to lower levels, till it passes beneath the bed of the stream. By extending these observations over the coal-field, it is found that the whole series of strata maintain their general arrangement, and the principal members of the group, such as an important coal-bed, a peculiar bed of limestone, etc., may be identified over areas of thousands of square miles. It is thus the sections have been prepared at many localities to complete the series, as presented on the opposite page, of the bituminous coal-measures of the extreme western part of Pennsylvania. The coal-beds introduced are those which are persistent over the greatest areas. Others occasionally appear in different parts of the column, and various other local differences may be detected, owing to the irregularities in the stratification; thus sandstones and slates often thin out, and even gradually pass from one into the other. By their thinning out beds of coal separated by them in one locality may come together in another, and form one large bed; and again, large coal-beds may be split by hardly perceptible divisional seams of slate or shale, which may gradually increase, till they become thick strata, separating what was one coal-bed into two or more. The limestones, though generally thin, maintain their peculiar characters much better than the great beds of sandstone or shale, and are consequently the best guides for designating in the columns the position of the strata which accompany them, above and below. The fire clay is almost universally the underlying stratum of the coal-beds. In the sections it is not distinguished from the shale-beds. The total thickness of all the measures, is from 2000 to 2500 feet.

Such is the general system of the coal-bearing formation west of the Alleghanies. Every farm and every hill in the coal-field is likely to contain one or more beds of coal, of limestone, of good sandstone for building purposes, of fire clay, and some iron ore; and below the surface, the series is continued down to the group of conglomerates and sandstones, which come up around the margins of the coal-fields and define their limits. At Pittsburg this group, it is found by boring, as well as by the measurements of the strata in the hills toward the north, is about 600 feet below the level of the river. The coal-measures in this portion of the country are the highest rock formation; but in the western territories beyond the Mississippi they pass under later geological groups, as the cretaceous and the tertiary. All the coals are bituminous, and the strata in which they are found are little moved from the horizontal position in which they were originally deposited. They have been uplifted with the continent itself, and have not been subjected to any local disturbences, such as in other regions have disarranged and metamorphosed the strata.

East of the Alleghanies, in the narrow, elongated coal-fields of the anthracite region, a marked difference is perceived in the position assumed by the strata, and also in the character of the individual beds. They evidently belong to the same geological series as the bituminous coal-measures, and the same succession of conglomerates, sandstones, and red shales, is recognized below them; but the strata have been tilted at various angles from their original horizontal position, and the formation is broken up and distributed in a number of basins, or canal-shaped troughs, separated from each other by the lower rocks, which, rising to the surface, form long narrow ridges outside of and around each coal-field. Those on each side being composed of the same rocks, similarly arranged, and all having been subjected to similar denuding action, a striking resemblance is observed, even on the map, in their outlines; and in the ridges themselves this is so remarkable that their shapes alone correctly suggest at once to those familiar with the geology of the country, the rocks of which they are composed. Upon the accompanying map, from the first vol. of the "New American Cyclopædia," these basins are represented by the shaded portions, and the long, narrow ridges which surround the basins, and meet in a sharp curve at their ends, are indicated by the groups of four parallel lines. Within the marginal hills the strata of the coal-measures, and of the underlying formations, while retaining their arrangement in parallel sheets, are raised upon their edges and thrown into undulating lines and sharp flexures; and the extrac-

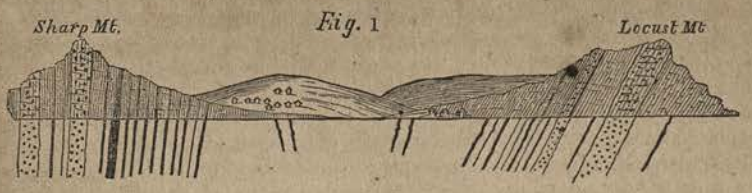


Fig. 1

tion of the coal, instead of being conducted by levels driven into the side of the hills, is effected by means of inclined shafts following down the course of the beds from the surface, or by vertical slopes sunk so as to cut them at considerable depths. The arrangement of the strata in its general features is represented in the accompanying wood cuts. Fig. 1 is a section from Sharp Mountain, on the south side of the Mauch Chunk summit mine, across this great body of coal, and the higher coal-beds of the formation repeatedly brought to the surface by their changes of dip, to Locust Mountain, which bounds the basin on the north. Fig. 2 is a section across the same basin at Tamaqua, six miles west from Mauch Chunk mine. In this section it is seen how the coal-measures are separated into basins by the lower rocks coming up to the surface and forming anticlinal axes. Fig. 3 represents the position of single beds, as they occur among the slates and sandstones, and the manner in which they are sometimes reached by means of a tunnel driven in from the base of the hill. The curved portion of the coal at the top is formed by the coal-beds at their outcrop becoming disintegrated, and their fragments and decomposed smut being spread down the slope of the hill. The Roman numerals, "IX," "X," "XI," "XII," in fig. 2, designate the lower formations of rock, known respectively as the red sandstones (corresponding to the "Old Red Sandstone"); a series of gray sandstones; one of red shales; and lastly, the conglomerate. The dotted lines above and below the section mark the continuity of the conglomerate beneath the base of the section and its original course above the present surface before this portion had been removed by diluvial action. The other formations obviously accompany the conglomerate with similar flexures.

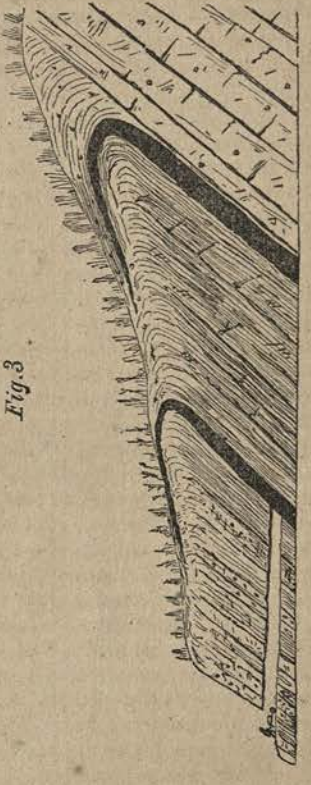


Fig. 3

Fig. 2

The same cause, that threw the strata into their inclined and contorted positions, no doubt changed the character of the coal by dispelling its volatile portions, converting it in fact into coke, while the pressure of the superincumbent beds of rock pre-

vented the swelling up of the material, as occurs in the ordinary process of producing coke from bituminous coal, and caused it to assume the dense and compact structure of anthracite. As the anthracite basins are traced westward, it is observed that the coals in those districts which have been less disturbed, retain somewhat of the bituminous character; and if the continuity were uninterrupted between the anthracite and the bituminous coal-fields, there is no doubt that a gradual passage would be observed from the one kind of coal to the other, and that this would be accompanied by an amount of disturbance in the strata corresponding to the degree in which the coal is deficient in bitumen.

AMOUNT OF AVAILABLE COAL.

In estimating the quantities of workable coal in any district, several points are to be taken into consideration besides the amount of surface covered by the coal-measures and the aggregate thickness of all the beds they contain. Where the strata spread out horizontally, as in the western coal-fields, extensive regions may be covered with a very thin portion of the coal-bearing strata, especially near the margins of the coal-fields; while in the deep basins, like those of the anthracite region, a number of large beds may be accumulated together in very limited districts. Then again, out of the total number of coal-beds, there are more or less of them that must be excluded from the estimate, on account of their being too thin to work; and as the thickness of all of them varies in different localities, a fair average thickness of workable beds is as difficult to arrive at as a fair average area into which this thickness is to be multiplied. The problem is rendered still more complex by the slopes and flexures of the strata in the districts east of the Alleghanies, and by the gaps between the hills which cut off the beds whose plane is above the lowest levels. The great depth at which lie the lower beds in the central parts of the Appalachian coal-field must probably prevent their ever being worked; but for this no allowance is ever made in the estimates of quantities of coal.

The most careful and complete computations of this nature which have been made are those of Professor H. D. Rogers, in vol. ii. of the Geology of Pennsylvania, page 1015. From this source we obtain the following estimates:—

EXTENT OF COAL-FIELD IN THE SEVERAL STATES POSSESSING THE COAL FORMATION.

	Sq. miles.
Massachusetts and Rhode Island	100
Pennsylvania	12,656
Ohio	7,100
Maryland	550
Virginia	15,900
Kentucky	13,700
Tennessee	3,700
Alabama	6,130
Georgia	170
Indiana	6,700
Illinois	40,000
Michigan	13,350
Iowa	24,000
Missouri	21,329
Nebraska	3,712
Kansas	11,880
Arkansas	12,597
Indian Territory	10,395
Texas	2,970
Total	196,939

In the anthracite basins of Pennsylvania the number of workable beds varies from 2 or 3 to 25, according to the depth of the basin; the average number is supposed to be 10 or 12. The maximum thickness of coal is in the Pottsville basin, and amounts to 207 feet. Rejecting the thin seams, the average thickness in the south anthracite field is reckoned at 100 feet; in the middle or north field at about 60 feet; and the general average of the whole, 70 feet.

The maximum thickness of the 15 or 16 coal-beds of the central part of the Appalachian coal-field is about 40 feet, but the average of the whole basin is considered to be 25 feet.

The basin extending over Illinois and into Indiana and Kentucky, contains in the last-named state 16 or 17 workable beds, with a maximum thickness of about 50 feet. The average over the whole area is supposed to be 20 or 25 feet.

The basin of Iowa, Missouri, and Arkansas contains only 2 or 3 workable beds, of total thickness not exceeding 10 feet; while the average for the whole area must be considerably less.

The following estimates of the number and thickness of the beds in some of the British coal-fields are introduced for comparison. The great coal-field of South Wales contains 23 workable beds of 92 feet thickness, averaging over the whole area probably 60 feet. The coal-beds in the South Staffordshire basin amount to 57 feet in thickness, and in one quarter to 70 feet. The average for the whole area is assumed

to be 40 feet. The Derbyshire coal-field has about 20 workable beds; aggregate thickness 66 feet, average 40 feet. The Lancashire and Cheshire coal-field in one district has 150 feet of coal in 75 beds, and in another 93 feet in 36 beds, some of which are too thin to be worked. Average thickness of workable coal over the whole field is supposed to be 50 or 60 feet. The Durham and Newcastle coal-field has total thickness of coal 60 feet, of workable coal 30 feet, and average about 20 feet. Over a total area of coal-fields in Great Britain, amounting to 5400 square miles, the average thickness of workable coal is supposed to be 35 feet. Extending these computations to Belgium and France also, Prof. Rogers presented the results of his calculations in tons as follows:—

RELATIVE AMOUNT OF COAL IN THE SEVERAL GREAT COAL-FIELDS OF EUROPE AND AMERICA.

	Tons.	Ratio.
Belgium (assuming an average thickness of about 60 feet of coal) contains about	36,000,000,000	1
France (with same thickness) contains about	59,000,000,000	1.64
The British Islands (averaging 35 feet thickness) contain nearly	190,000,000,000	5.28
Pennsylvania (averaging 25 feet thickness) contains	316,400,000,000	8.8
The great Appalachian coal-field (including Pennsylvania, averaging 25 feet)	1,387,500,000,000	38.5
Coal-field of Indiana, Illinois, and western Kentucky (average thickness 25 feet)	1,277,500,000,000	35.5
The Missouri and Arkansas basin (averaging 10 feet)	739,000,000,000	20.5
All the productive coal-fields of North America (with an assumed thickness of 20 feet of coal, and a productive area of 200,000 square miles)	4,000,000,000,000	111.
All the coal-fields of Europe	..	8.75

The following table contains the yearly returns of the coal product of eastern Pennsylvania and Maryland, from the commencement of the trade in 1820:—

STATISTICS OF PRODUCTION.

Year.	SCHUYLKILL.			WYOMING REGION.				
	Canal.	Railroad.	Total.	Del. & Hud. Coal Co.	Penn. Coal Co.	By canal.	D. L. & W. railroad.	Total tons.
1820	..	..	..	..	..	..	..	..
1821	..	..	..	..	..	..	..	..
1822	1,480	..	1,480	..	..	..	..	..
1823	1,128	..	1,128	..	..	..	..	..
1824	1,587	..	1,587	..	..	..	..	..
1825	6,500	..	6,500	..	..	..	..	..
1826	16,763	..	16,763	..	..	..	..	..
1827	31,360	..	31,360	..	..	..	..	..
1828	47,284	..	47,284	..	..	..	..	..
1829	79,973	..	79,973	7,000	..	..	..	7,000
1830	89,984	..	89,984	43,000	..	..	..	43,000
1831	81,854	..	81,854	54,000	..	..	..	54,000
1832	209,271	..	209,271	84,600	..	..	..	84,600
1833	252,971	..	252,971	111,777	..	..	..	111,777
1834	226,692	..	226,692	43,700	..	..	..	43,700
1835	339,508	..	339,508	90,000	..	..	..	90,000
1836	432,045	..	432,054	103,851	..	..	..	103,861
1837	523,152	..	523,152	115,387	..	..	..	115,387
1838	433,875	..	433,875	78,207	..	..	..	78,207
1839	442,608	..	442,608	122,300	..	..	..	122,300
1840	452,291	..	452,291	148,470	..	..	..	148,470
1841	514,692	850	515,542	192,270	..	..	..	192,270
1842	461,602	49,902	502,504	205,253	..	47,346	..	252,599
1843	447,058	230,254	677,312	227,605	..	58,000	..	285,605
1844	393,887	441,491	835,288	251,005	..	114,906	..	365,911
1845	263,587	820,237	1,083,824	273,435	..	178,401	..	451,836
1846	3,440	1,263,144	1,266,584	320,000	..	192,503	..	512,503
1847	222,693	1,360,361	1,583,054	388,203	..	284,398	..	672,601
1848	486,602	1,216,233	1,652,835	437,500	..	237,271	..	674,771
1849	489,208	1,115,918	1,605,126	454,240	..	259,080	..	713,320
1850	288,080	1,423,977	1,712,057	441,403	111,014	243,250	..	795,667
1851	579,156	1,602,727	2,181,883	479,078	316,017	386,000	6,000	1,131,095
1852	800,932	1,663,117	2,464,049	497,105	426,164	319,341	67,487	1,310,097
1853	888,869	1,587,211	2476,080	494,327	512,659	442,511	97,358	1,546,855
1854	907,354	1,983,478	2,890,832	440,944	496,648	492,689	133,964	1,564,245
1855	1,105,263	2,213,292	3,319,555	565,460	504,803	464,039	188,865	1,723,167
1856	1,169,286	2,148,903	3,318,189	499,650	612,500	510,631	296,232	1,919,013
1857	1,275,989	1,672,544	2,948,533	480,677	543,873	405,822	490,023	1,920,395
1858	1,323,804	1,542,592	2,866,396	348,789	630,056	350,000	680,500	2,009,345
1859	1,371,753	1,633,150	3,004,903	590,839	688,855	433,548	830,600	2,543,242
1860	1,356,688	1,578,867	3,235,555	499,568	691,465	430,242	1,077,500	2,698,775
Total,	17,970,239	25,848,158	43,818,382	9,089,643	5,534,054	5,799,978	3,867,929	24,291,604

STATISTICS OF PRODUCTION.—CONTINUED.

Year.	LEHIGH.			SEMI-ANTHRACITE.					BITUMINOUS.		Aggregate.
	Canal.	Railroad.	Total.	Shamokin.	Lykens Valley.	Dauphin & S. R.	Trevorton.	Broadtop.	Blossburg.	Barclay.	
1820	365	..	365	..	..	..	..	..	..	..	365
1821	1,073	..	1,073	..	..	..	..	..	..	..	1,073
1822	2,240	..	2,240	..	..	..	..	..	..	..	3,720
1823	5,823	..	5,823	..	..	..	..	..	..	..	6,951
1824	9,541	..	9,541	..	..	..	..	..	..	..	11,108
1825	28,393	..	28,393	..	..	..	..	..	..	..	34,893
1826	31,280	..	31,280	..	..	..	..	..	..	..	48,043
1827	32,074	..	32,074	..	..	..	..	..	..	..	63,430
1828	30,232	..	30,232	..	..	..	..	..	..	..	84,613
1829	25,110	..	25,110	..	..	..	..	..	..	..	148,083
1830	41,750	..	41,750	..	..	..	..	..	..	..	185,734
1831	40,966	..	40,966	..	..	..	..	..	..	..	207,420
1832	70,000	..	70,000	..	..	..	..	..	..	..	363,871
1833	123,000	..	123,000	..	..	..	..	..	..	..	487,748
1834	106,244	..	106,244	..	..	..	..	..	..	..	376,636
1835	131,250	..	131,250	..	..	..	..	..	..	..	560,758
1836	148,211	..	148,211	..	..	..	..	..	..	..	684,126
1837	223,902	..	223,902	..	..	..	..	..	..	..	862,441
1838	213,615	..	213,615	..	..	..	..	..	..	..	725,697
1839	221,025	..	221,025	11,930	..	..	..	..	..	..	797,863
1840	225,318	..	225,318	15,505	..	..	..	..	4,235	..	845,819
1841	143,037	..	143,037	21,463	..	..	..	..	25,966	..	898,278
1842	272,546	..	272,546	10,000	..	..	..	..	18,164	..	1,050,813
1843	267,793	..	267,793	10,000	..	..	..	..	6,268	..	1,246,978
1844	377,002	..	377,002	18,087	..	..	..	..	14,234	..	1,605,522
1845	429,453	..	429,453	10,000	..	..	..	..	29,836	..	2,004,949
1846	517,116	..	517,116	12,572	..	..	..	..	16,509	..	2,325,284
1847	633,507	..	633,507	14,904	..	..	..	..	29,987	..	2,923,153
1848	670,321	..	670,321	19,356	..	..	..	..	33,762	..	3,042,045
1849	781,656	..	781,656	19,650	25,325	..	..	..	32,095	..	3,177,172
1850	690,456	..	690,456	19,921	37,763	..	..	..	23,161	..	3,279,025
1851	964,224	..	964,224	24,899	52,060	20,000	..	..	25,000	..	4,400,161
1852	1,072,136	..	1,072,136	25,846	55,000	33,639	..	..	20,000	..	4,980,767
1853	1,054,309	..	1,054,309	15,500	60,000	29,000	..	..	45,571	..	5,227,315
1854	1,207,186	..	1,207,186	63,500	58,000	63,000	..	..	70,554	..	5,912,317
1855	1,275,050	9,063	1,284,113	116,117	112,000	52,494	..	..	73,201	..	6,680,647
1856	1,186,230	165,740	1,354,970	117,406	100,000	77,307	73,142	42,000	70,670	4,115	7,106,782
1857	900,314	418,236	1,318,550	153,525	121,550	82,285	110,711	78,812	94,314	6,239	6,834,914
1858	908,800	471,029	1,379,829	137,000	127,750	..	106,686	105,478	40,001	18,000	6,790,485
1859	1,050,592	577,651	1,628,243	180,000	139,200	..	124,250	130,387	..	30,143	7,780,368
1860	1,091,032	730,642	1,821,674	211,100	176,290	..	89,515	188,250	..	30,000	8,451,159
Total,	17,204,172	2,372,361	19,576,533	1,258,281	1,059,938	357,725	504,274	544,927	667,626	88,597	92,222,526

In presenting the statistics of the product of the principal coal districts of the United States, it will be observed that these are limited to the eastern portion of Pennsylvania and the Cumberland district of Maryland. It is from these sources almost exclusively that the great markets of the New England states, of the states of New York and New Jersey, and of the eastern portion of Pennsylvania and Maryland have been supplied; and it is from the records preserved by the lines of transportation from the mines that any statistics of the coal products are now available. In the Western states, where the bituminous coal-beds are very generally distributed over large territories, there exists no concentration of the business, as at the East, and no means are afforded of obtaining even an approximate estimate of the amount of coal annually mined.

TRANSPORTATION OF COAL TO MARKET.

The first anthracite from the Schuylkill mines was brought to Philadelphia in wagons. The navigation of the river and canal was hardly practicable for boats previous to the year 1822; and though from that year anthracite was conveyed to Philadelphia and the trade continued to increase, it was not until after the improvements were completed in 1825, that a large amount of coal could be transported by this route. The effect of these improvements was experienced in the transportation of 6500 tons in 1825, which was more than four times the business of 1824; and in 1826 it increased to 16,763, and this nearly doubled in the succeeding year. As for successive years the trade steadily and rapidly increased in importance, the capacity of the canal proved at last insufficient for it, and the Reading railroad was laid out especially for its accommodation, and constructed with a uniform descending grade from the mining region at Pottsville to the Delaware river. This went into operation in 1841, and proved a formidable competitor to the Schuylkill canal, but the still increasing

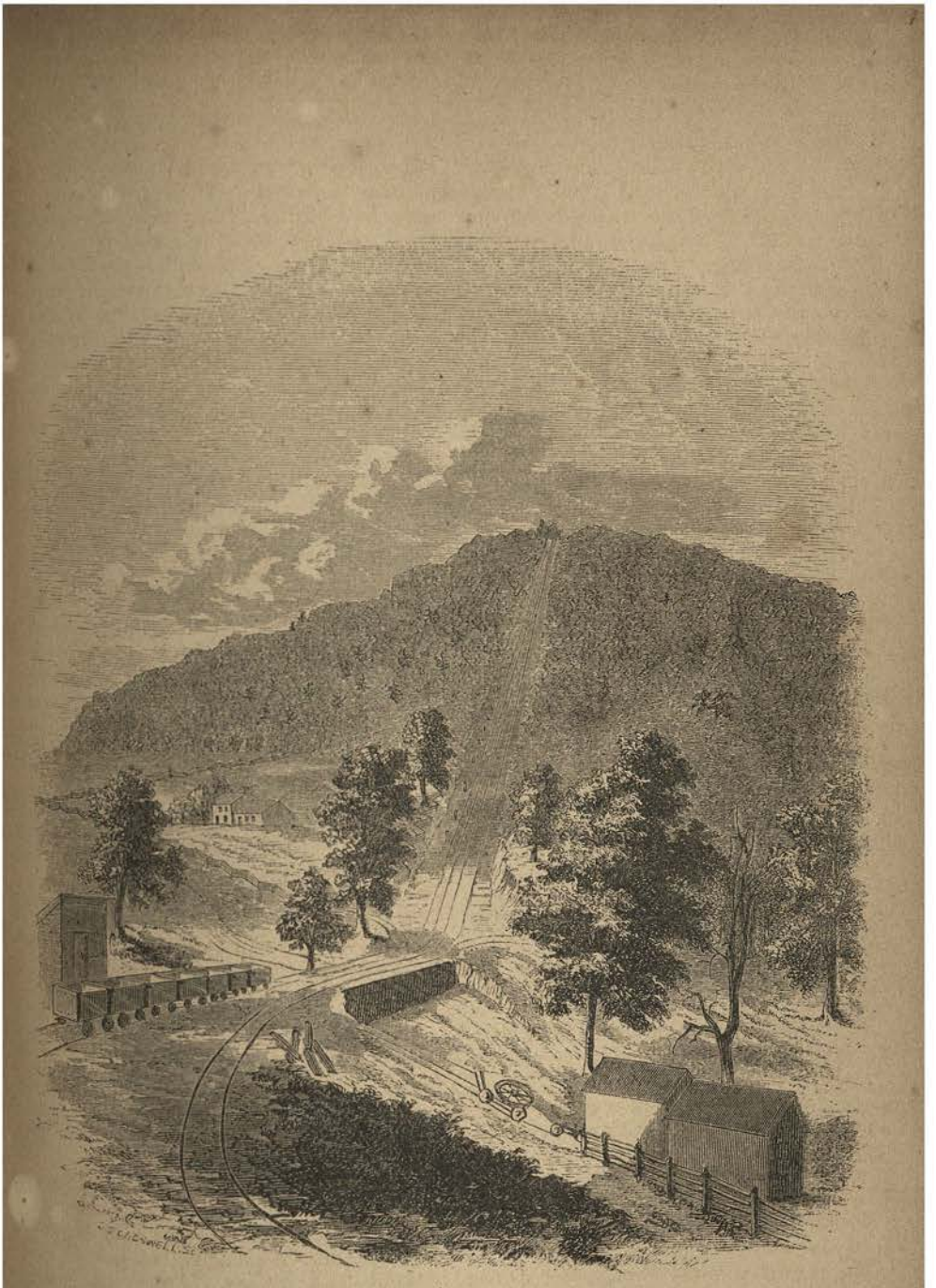
trade has well nigh reached the capacity of both these routes. The greatest amount of coal transported in one year by any one line was in 1855 over the Reading road, being 2,213,392 tons. The number of tons carried by canal the same year was 1,105,263 tons. Since that time the business has been more equally divided between them, the railroad still doing the larger portion of it.

As seen by the table, the first shipments of anthracite were from the Lehigh region, two years before any were sent from the Schuylkill. The transportation was effected by arks or large boxes built of plank, and run down the rapid and shoal river with no little risk. To return with them was impracticable, nor was this desired, for the arks themselves were constructed of the product of the forests, which in this form was most conveniently got to market. They had before been the chief means of conveyance down into the Delaware of the products of the country, which indeed were little else than lumber. As the coal trade increased in importance, the improvement of the river was undertaken by the Lehigh Coal and Navigation Company to insure greater facility in running the arks. They constructed dams across the shoaler places in the river, by which the water was held back, thus increasing the depth above. As the arks coming down the river reached one of these dams, the sluice gates were opened and the boats descended into the next division in which the water was kept up by the next dam below. At first two arks were used together, being connected by hinges at the ends; and as the facilities for running them were improved, more of them were thus joined together, till they reached nearly 200 feet in length. In 1831 the slack-water navigation of the Lehigh was so far perfected, that it was used by canal boats ascending and descending through regular locks.

Up to the year 1827 the transportation of anthracite to Mauch Chunk from the mines, nine miles distant, had been by a wagon road. In January of that year the construction of a railroad was commenced, and in May the road was completed. This was the second railroad built in the United States, the first one being a short road from the granite quarries in Quincy, Massachusetts. The Mauch Chunk road was made with a descending grade all the way, averaging about 100 feet to the mile, so that the loaded cars ran down by gravity. Each train carried down with it in cars appropriated to this use the mules for drawing the empty cars back; and it is stated that after the animals once became accustomed to the routine of their duties they could never be made to travel down the road if accidentally left behind. The trade before many years outgrew these increased facilities of transporting the coal, and it was found essential to provide a new track, upon which the empty cars could be returned by some more economical method. On account of the heavy up-grade, locomotives, it was concluded, could not be advantageously employed, and hence a system of inclined planes and gravity roads was devised, by which the cars hoisted by stationary power to the summit of the planes and thence descending the gravity roads might be returned to the mines, and the use of mules and horses be entirely dispensed with. In the accompanying sketches a part of this arrangement of roads is exhibited.

The high hill called Mount Pisgah, above the village of Mauch Chunk, is the terminating point at the Lehigh river of the long ridge called Sharp Mountain. The great mines of the Lehigh are on its summit about nine miles west of the village. The lower road seen in the sketch is called the loaded track. The cars come by this from the mines, and being let down the inclined plane at its terminus, their loads are discharged into the great bins over the edge of the river. They are then hauled a short distance to the foot of the long plane that reaches to the summit of Mount Pisgah, and by the stationary steam engine are drawn up in about six minutes to an elevation 850 feet above that at the foot. The length of this plane is 2250 feet. From its summit the empty cars run down the inclined road constructed along the south side of the ridge, and at the distance of six miles, having descended about 300 feet, they reach the foot of another inclined plane at Mount Jefferson. This plane is 2070 feet long, rising 462 feet. The ascent is accomplished in three minutes, and from the top another gravity road extends about a mile, descending 44 feet to the Summit Hill village. From this point branch roads lead to the different mines in Panther Creek valley, and all meet again in the loaded track road by which the cars return to Mauch Chunk.

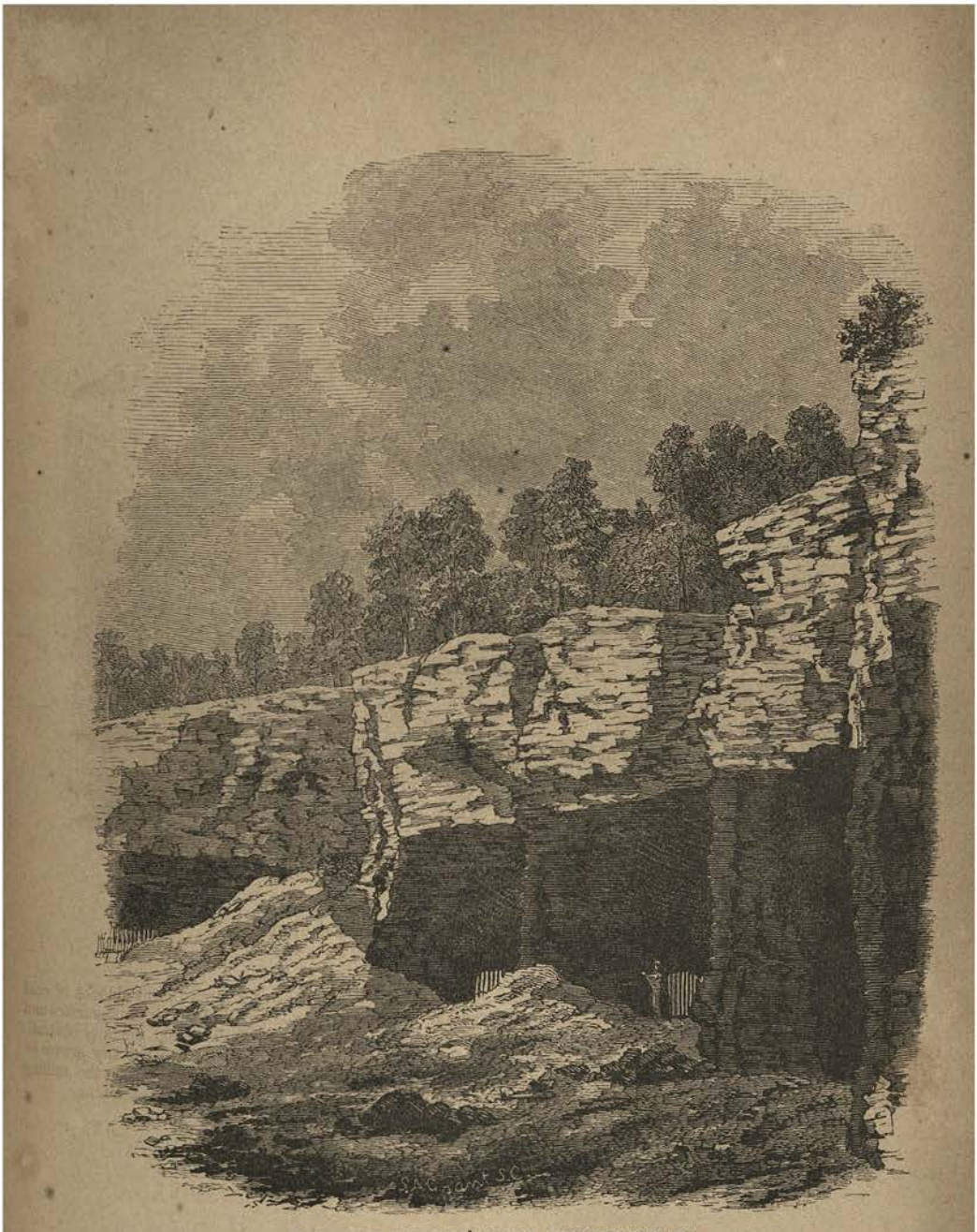
The transportation of coal from Mauch Chunk was conducted by the river and canal



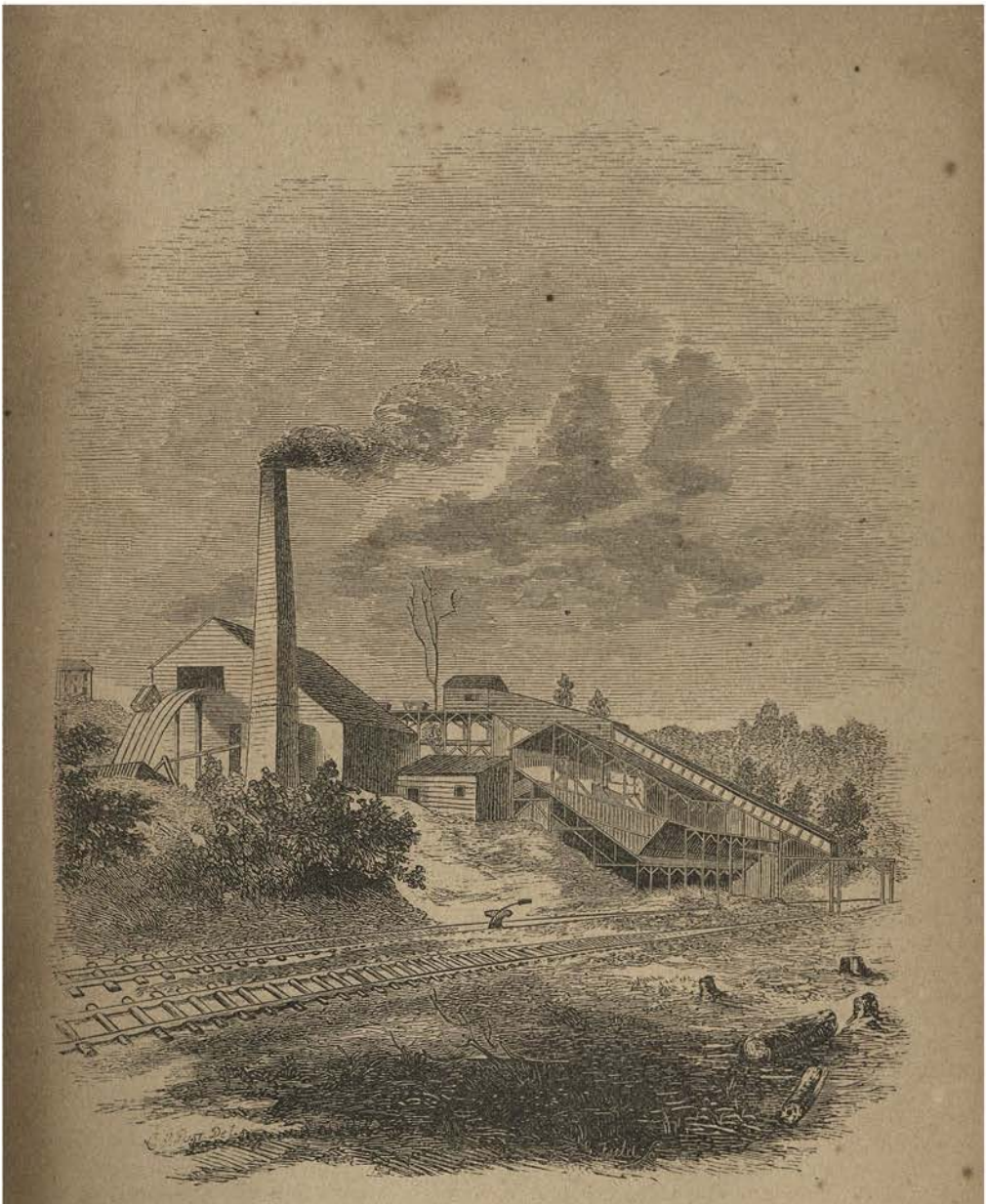
MOUNT PISGAH PLANE, MAUCH CHUNK, PA.

THE GREAT OPEN QUARRY OF THE LEHIGH.

In working this great quarry of anthracite at the Summit mine, above Mauch Chunk, blocks of coal were occasionally left standing for a time, one of which, surmounted by the soil of the original surface and the relics of the vegetation, is represented in the above cut. In this block are discerned the lines of stratification of the coal; and an idea of its extraordinary thickness and extent is conveyed by the appearance of the cliffs upon the further side of the excavated area. Upon the floor of the quarry are seen the mining wagons used for conveying away upon temporary tracks the coal and rubbish of the excavations.



BALTIMORE COMPANY'S MINE, WILKESBARRE, PA.



COLLIERY SLOPE AND BREAKER AT TUSCARORA, PA.

MOUNT PISGAH PLANES AND THE GRAVITY RAILROAD, MAUCH CHUNK.

exclusively until the partial construction of the Lehigh railroad in 1846. But it was not until its completion in 1855, that this began to be an important outlet of the coal region and a powerful competitor for the trade with the canal.

A considerable amount of anthracite finds a market on the borders of Chesapeake Bay, being transported from the mines near the Susquehanna river by the Susquehanna tide-water canal, and by the Baltimore and Susquehanna railroad. Its consumption is extending in this region by its use in the blast furnaces in the place of charcoal, for smelting iron ores, and the receipts of this fuel in the city of Baltimore are steadily gaining upon those of the semi-bituminous coals of the Cumberland region, which are brought to the city by the Baltimore and Ohio railroad. For four years past these receipts have been as follows:—

	1857. Tons.	1858. Tons.	1859. Tons.	1860. Tons.
Bituminous	443,782	331,865	344,223	397,684
Anthracite	257,334	277,967	258,189	325,129
	701,116	609,832	602,412	722,813

The principal outlet of the Northern coal-field had been from 1829 to 1850 by the Delaware and Hudson canal. Since 1847 there have been taken every year to the Hudson river by this route from about 440,000 to 499,650 tons, except in 1855, when the quantity was 565,460 tons. A number of railroads now connect this basin with the central railroad across northern New Jersey, and in other directions it is connected both by railroad and canals with the Erie railroad to the North and the Susquehanna river to the South-west. As large an amount of coal is now transported over each one of three of these lines as by the Delaware and Hudson canal.

The various railroads and canals which have been constructed with especial reference to the transportation of anthracite, are more than 40 in number, and have cost about $93,000,000. Most of them are presented in the following table; of some of them only those portions which may fairly be counted as constructed for coal purposes:—

Names of railroads and canals.	Canals. No. miles.	Railroads. No. miles.	Total cost.
Lehigh Navigation	87	..	$4,455,000
Lehigh and Susquehanna railroad	..	20	1,350,000
Mauch Chunk and Summit railroads	..	36	831,684
Delaware division of the Pennsylvania canal	43	..	1,734,958
Beaver Meadow railroad and branch	..	38	360,000
Hazleton railroad	..	10	120,000
Buck Mountain railroad	..	4	40,000
Summit railroad	..	2	20,000
Lehigh Valley railroad	..	45	3,500,000
Delaware and Hudson canal	108	..	3,250,000
Morris canal	102	..	4,000,000
The Schuylkill Navigation	108	..	5,785,000
Reading and Pottsville railroad	..	98	19,004,000
Shamokin and Pottsville Valley railroad	..	30	900,000
Little Schuylkill railroad	..	28	1,416,187
Danville and Pottsville railroad (44½ miles unfinished)	..	29	680,000
Mine Hill and Schuylkill Haven railroad and branches	..	100	2,800,000
Mount Carbon railroad	..	7	155,000
Port Carbon railroad	..	2	120,000
Schuylkill Valley railroad and branches	..	25	300,000
Mill Creek railroad	..	6	120,000
Lykens Valley railroad	..	16	200,000
Wiconisco canal	12	..	370,000
Swatara railroad	..	4	20,000
North Branch canal	163	..	3,790,310
Union canal and Pine Grove branch	90	..	1,000,000
Schuylkill and Susquehanna railroad	..	52	1,500,000
Northern Central railroad	..	60	1,000,000
Pennsylvania canal (from Wilkesbarre to Columbia)	100	..	3,000,000
Susquehanna tidewater canal	45	..	1,000,000
York and Cumberland railroad	..	26	600,000
Cumberland Valley railroad	..	56	1,192,111
Franklin railroad	..	22	450,000
Nesquehoning railroad	..	5	50,000
Room Run railway	..	6	40,000
Delaware, Lackawanna, and Western railroad	..	170	9,995,000
Lackawanna and Bloomsburg railroad	..	68	1,600,000
Quakake railroad	..	14	280,000
Catawissa, Williamsport, and Erie railroad	..	65	4,145,096
Elmira and Williamsport	..	78	2,000,000
Pennsylvania Coal Company's railroad	..	52	3,745,500
New Jersey Central railroad	..	63	5,746,366
Railroads by individuals	..	120	180,000
Underground railroads	..	200	75,000
Total	858	1,557	$92,921,212

COAL MINING.

Coal-beds are discovered and worked by different methods, varying according to the circumstances under which they occur. In regions where they lie among the piles of strata horizontally arranged, and passing with the other members of the group upon a level or nearly so through the hills, their exact position is often detected by their exposure in the precipitous walls of rock along the rivers; or it is indicated by peculiar indentations, known as "benches," around their line of outcrop, caused by their crumbling and wearing away more rapidly than the harder strata above and below them; and again by the recurrence of springs of water and wet places at the foot of the benches, which point to an impervious stratum within the hill that prevents the water percolating any further down; and lastly, in the little gorges worn by the "runs," the beds are often uncovered, and loose pieces of coal washed down lead to their original source above. However discovered, the method of working them is simple. A convenient place is selected upon the side of a hill, and an excavation called a drift, usually about four feet wide, is made into the coal-bed. The height of the drift is governed by the thickness of the coal-bed and the nature of the overlying slate. Miners sometimes work in drifts only 2½ feet high. Coal-beds three or four feet thick are very common, and are

worked without the necessity of removing the overhanging slate, unless it is too unsound to serve as a roof. Beds of ten feet thickness or more require much additional care over those of smaller size, both in removing the coal and supporting the roof; and in many cases it is found expedient to leave a portion of the bed, either at the top or bottom, untouched, especially if the upper layers contain, as they often do, sound sheets of slate. At the entrance of the mines, and in general in all places where the cover is not sound, the materials overhead are prevented from falling by timbers across the top of the drifts, rudely framed into posts set up against the walls on each side; and where the strata are very loose, slabs are driven in over the cross timbers and behind the posts. In such ground the coal cannot be excavated over large areas without leaving frequent pillars of coal and introducing great numbers of posts or props. But previous to abandoning the mine the pillars may be removed, commencing with those furthest in, and all the strata above are thus allowed to settle gradually down. When drifts or gangways have been extended into the coal-beds far enough to be under good cover, branches are commenced at right angles, and a system of chambers is laid out for excavation, leaving sufficient blocks or pillars of coal to provide for the support of the overlying strata. Thus the work is carried on, ventilation being secured by connections made within the hill with gangways passing out in different directions, and sometimes also by shafts sunk from the surface above, or, when these means are not practicable, by ventilating fans worked by hand, and thus forcing air through long wooden boxes which lead into the interior of the mine. Drainage is often a serious trouble, and unless the strata slope toward the outlet of the mine, it can be effected only by a channel cut to the required depth for the water to flow out, or else by the use of pumping machinery. When the strata lie nearly upon a horizontal plane, it is very common for a slight descent to be found from the exterior of a hill toward its centre, as if the beds of rock had been compressed and settled by their greater weight in the middle of the hill. In such positions the coal is extracted with much expense for drainage, and it is therefore an important consideration in judging of the value of coal-beds to ascertain whether or no the water will flow freely out from the excavations. In the bituminous coal-fields west of the Alleghanies, owing to the general distribution of the coal-beds above the level of the water-courses, it has not yet been found worth while to work any of the beds that are known to lie below this level. Coal must reach a much higher value before beds of the moderate size of those in that region can be profitably explored below water level.

It is rare that bituminous coal is obtained by open quarrying. Where the beds lie near the surface, so that they might be uncovered, the coal is almost invariably in a rotten condition and worthless. Consequently one of the first points to be assured of in judging of the value of a coal-bed is that it has sufficient rock cover. After this may be considered the quality of the coal, its freedom from sulphur, etc., the soundness of its roof, and the facilities offered for drainage and ventilation. The quality of a coal-bed undergoes little or no change after it is once reached under good cover beyond atmospheric influences; and hence no encouragement can be given to continuing to work a poor bed in hopes of its improving.

Coal is excavated chiefly by light, slender picks. With one of these a miner makes a shallow, horizontal cut as far as he can reach under the wall of coal before him, stretching himself out upon the floor to do this work, and then he proceeds to make a vertical cut extending from each end of that along the floor up to the roof. By another horizontal cut along the roof, a cubical block of coal is thus entirely separated from the bed, except on the back side which cannot be reached. The separation is completed by wedges driven into the upper crevice, or sometimes by small charges of powder. By this means blocks of coal are thrown down amounting to 70 or 80 tons in weight, and with the least possible loss by the reduction of portions of it to dust and fine coal.

The cost of mining and delivering coal at the mouth of the mines, varies with the size and character of the beds. Under the most favorable conditions the horizontal beds of bituminous coal, as those in the hills opposite Pittsburg, have been worked and the coal delivered outside for 1½ cents a bushel, or 45 cents a ton; but in general the total expenses are nearly double this rate. In estimating the capacity of production of coal-beds it is usual to allow a ton of coal to every cubic yard, and a bed of coal a yard thick should consequently contain a ton to

every square yard, or 4840 tons to the acre: but the actual product that can be depended on, after the loss by fine coal, by pillars left standing, etc., may not safely be reckoned at more than 3000 tons, or for every foot thickness of the bed 1000 tons.

In the anthracite region, and in other coal districts where the beds are of large size and lie at various degrees of inclination with the horizon, the methods of mining differ more or less from those described. The anthracite beds frequently extend in parallel layers longitudinally through the long ridges, dipping, it may be, nearly with the outer slope, and descending to great depths below the surface. In such positions they are conveniently reached at the ends of the ridges and in the gaps across these, by a level driven on the course of the bed, and rising just enough for the water to drain freely. A level or gangway of this sort is the great road of the mine, by which all the coal is to be brought out in case other similar gangways are not driven into the same bed at points further up or down its slope. Unless the dip is very gentle, one at the lowest point should be sufficient. At different points along its extension passageways are cut in the coal, directed at right angles up the slope of the bed, and as soon as one of them can be brought through to the surface, a ventilating current of air is established, which may afterward be diverted through all the workings. The passageways together with other levels above divide the coal-bed into great blocks, and also serve as shutes by which the coal excavated above is sent down to the main gangway. At the bottom of each shute a bin is constructed for arresting the coal and discharging it, as required, into the wagons which are run in beneath on the tracks laid for this purpose. Coal-beds in this position are also worked from the gangway by broad excavations carried up the "breast" or face of the bed, sufficient pillars of coal from 12 to 25 feet long being left in either case to support the roof. These pillars usually occupy the most room just above the gangways, and on passing up between them, the chambers are made to widen out till they attain a breadth of about 40 feet, and thus the breast is extended up to the next level. Props are introduced wherever required to support the roof, and the rubbish, slates, etc., are stacked up for the same purpose, as well as to get them out of the way.

It often occurs that coal-beds within the ridges can be reached only by a tunnel driven in from the side of the mountain across their line of bearing. Tunnels of this kind are sometimes extended till they cut two or more parallel coal-beds. Each one may then be worked by gangways leaving the tunnel at right angles and following the coal-beds, and the tunnel continues to be the main outlet of them all.

When it is desirable to obtain the coal from the portion of the bed below the level of the gangway, preparations must first be made for raising the water, which may be done for a time by bucket and windlass, and as the slope is carried down and the flow of water increases, then by mining pumps worked by horse or steam power. The slope may commence from the exterior surface or from the lower gangway of a mine already in operation, and is made large enough to admit wagons, which ascend and descend upon two tracks extending down its floor. At the depth of 200 or 300 feet a gangway is driven at right angles with the slope in each direction on the course of the bed, and from this the workings are carried up the breast as already described. Other gangways are started at lower levels of 100 feet or more each, dividing the mine into so many stories or floors. The coal above each gangway is sent down to its level and is received into wagons. By these it is conveyed to the slope, and here running upon a turn-table, each wagon is set upon the track in the slope and is immediately taken by the steam engine to the surface, another car at the same time coming down on the other track. Reservoirs are constructed upon the different levels to arrest the water, that it may not all have to be raised up from the bottom, and the pumps are constructed so as to lift the water from the lower into the higher reservoirs and thence to the surface. Many mines of this character are opened from the surface, one of which is represented in the cut of the "Colliery Slope and Breaker, at Tuscarora, Pennsylvania." An empty wagon is seen in this cut descending the track from the engine house down into the mouth of the pit, and through the end of the building passes the pump rod which by means of a vibrating "bob" is turned down the pit and works by the side of the track. The men pass down into the mines of this character, sometimes by the wagons, and sometimes by

ladders or steps arranged for the purpose between the two tracks. Though the opening, as represented, appears insignificant for an important mine, such a slope may extend several hundred feet in depth, and many gangways may branch off from it to the right and left, extending several miles under ground in nearly straight lines along the course of the bed. These, however, to secure ventilation, must have other slopes coming out to the surface, and at these may be other arrangements for discharging the coal and water. In extensive mines the gangways are made wide and capacious for the continual passing back and forth of the wagons drawn by mules. These animals once lowered into the mine are kept constantly under ground, where they are provided with convenient stables excavated from the coal and rock. The men continue at work from eight to ten hours, and in well-ventilated mines the employment is neither very laborious, hazardous, nor disagreeable. The pursuit has, however, little attraction for Americans, and is mostly monopolized by Welsh, English, Irish, and German miners.

In the anthracite region there have been some remarkable instances of open quarries of coal. That of the Summit mine of the Lehigh is unsurpassed in the history of coal mining, for the enormous body of coal exposed to view. The great coal-bed, which appears to have been formed by a number of beds coming together through the thinning out of the slates that separated them, arches over the ridge, forming the uppermost layers of rock, and dipping down the sides at a steeper angle than their inclination. It thus passes beneath the higher strata. On the summit a thin soil, formed chiefly of the decomposed coal itself, covered the beds and supported a growth of forest trees. For several feet down the coal was loose and broken before the solid anthracite was reached. As the excavations were commenced and carried on from this point, it appeared as if the whole mountain was coal. Shafts were sunk into it and penetrated repeated layers of anthracite, separated by thin seams of slate, to the depth, in some places, of more than 55 feet. The work of stripping off and removing the covering of yellow and greenish sandstones and refuse coal was carried on, till the quarry had extended over about 50 acres, and on the north side the overlying sandstone, which had been steadily increasing in thickness, presented a wall of 30 to 40 feet in height. Over this area rail tracks were laid for removing the waste northward to the slope of the hill toward the Panther Creek valley; and when the piles thus formed had grown into large hills, the rubbish was deposited in the spaces left after the coal had been removed. During the progress of this work the scenes presented were of the most picturesque and novel character. The area laid bare was irregularly excavated into steps, upon which temporary rail tracks were laid in every direction. Upon these the wagons were kept busily running, some carrying off the coal, some loaded with slates and waste, and others returning empty for their loads. Here and there stood huge isolated masses of anthracite, with their covering of sandstone, soil, and the relics of the original forest growth, reaching to the height of 50 or 60 feet, monuments of the vast amount of excavation that had been carried on, and presenting in their naked, vertical walls, fine representations of the extraordinary thickness of the bed and of the alternating layers of slate and coal of which it was composed. In the accompanying cut of the great open quarry of the Lehigh is represented one of these blocks. Gradually these masses disappeared as the miners continued their operations; but in the boundary walls of the quarry there are still to be seen black cliffs of solid coal more than 50 feet high, and overtopped by a wall of yellow sandstone of nearly equal additional height. Under these walls operations have been carried on by the regular system of underground mining. From ten acres of the quarry it has been estimated that 850,000 tons of coal have been sent away, the value of which in the ground at the usual rate of 30 cents per ton, would be $255,000, or $25,500 per acre. Estimating the average working thickness of the coal in this part of the coal-field, from the Little Schuylkill to Nesquehoning, at 40 feet, which according to the report of the state geologist is not exaggerated, every available acre contains not less than 65,000 tons. The expense of extracting and preparing the coal from the great bed for market, is stated by the same authority to be 37½ cents per ton for mining and delivering ready for breaking and cleaning. For this operation 12½ cents; and for raising it to the summit and running it to Mauch Chunk 25 cents.

Another locality where coal has been

worked by open quarrying is at the mines of the Baltimore Company, near Wilkesbarre. Here, too, an immense bed of coal was found so close to the surface that it was easily uncovered over a considerable area. As the overlying slates and sandstone increased in thickness, it was found at last more economical to follow the coal under cover; and it was then worked after the manner of mining the bituminous coal-beds west of the Alleghany Mountains. Horizontal drifts 25 feet high, which was the thickness of the bed, were carried in from the abrupt wall, several of them near together and separated by great pillars of coal left to support the roof. The gangways were so broad and spacious that a locomotive and train of cars might have been run into the mine. Within they were crossed by a succession of other levels, and through the wide spaces thus left open, the light of day penetrated far into the interior of the hill, gradually disappearing among the forest of black pillars by which it was obstructed and absorbed.

In the anthracite region, several coal-beds of workable dimensions are often found in close proximity, so that when dipping at a high angle they are penetrated in succession by a tunnel driven across their line of bearing. Larger quantities of coal are thus concentrated in the same area than are ever met with in the bituminous coal-field. In the northern coal-fields, between Scranton and Carbondale, tracts have brought $800 or more per acre, and single tracts of 650 to 700 acres are reported upon by competent mining engineers as containing five workable beds, estimated to yield as follows—each one over nearly the whole area: one bed working 7 feet, 11,200 tons per acre; a second, working 8 feet, 12,800 tons per acre; a third, 6 feet, 9600 tons per acre; a fourth, the same; and a fifth, 3 feet, 4800 tons—altogether equalling a production of 48,000 tons per acre, from which 20 per cent. should be deducted for mine waste, pillars, etc.

The anthracite as usually brought out from the mines is mostly in large lumps of inconvenient size to handle. In this shape it was originally sent to market, and when sold to consumers a man was sent with the coal to break it up in small pieces with a hammer. At present every mine is supplied with an apparatus called a coal-breaker, which is run by steam power, and which crushes the large pieces of coal in fragments. It consists of two rollers of cast iron, one solid, with its surface armed with powerful teeth, and the other of open basket-work structure. These revolve near together, and the coal, fed from a hopper above, is broken between them, and the pieces discharged below into another hopper are delivered into the upper end of a revolving cylindrical screen, made of stout iron wire, and set on a gentle incline. The meshes of this screen are of four or more degrees of coarseness. At the upper end the finer particles only drop through; passing this portion of the screen, the coarser meshes which succeed let through the stove coal sizes, next the "egg coal," and next the "broken coal," while the coarsest pieces of all, called "lump coal," are discharged through the lower end of the screen. Under the screen are bins or shutes, separated by partitions, so as to keep each size by itself. Their floor slopes down to the railway track, and each bin at its lower end is provided with a trap-door, through which the coal is delivered as required into the wagons. The general plan of this arrangement is seen in the preceding wood-cut of the Colliery Slope and Breaker at Tuscarora. The coal wagons are here run from the mine up into the top of the engine house, and thence through the building to the breaker at the upper end of the slope over the shutes. As the coal falls from the screen into these, boys are employed, one in each bin, to pick out and throw away the pieces of slate and stone that may be mixed with the coal. This they soon learn to do very thoroughly and with great activity; and upon the faithfulness with which their work is done depends in no small measure the reputation of the coal.

USEFUL APPLICATIONS.

While anthracite, by reason of its simple composition, is fitted only for those uses in which the combustion or oxidation of its carbon is required to generate heat, or else to extract oxygen from other substances, the bituminous coals, containing a greater variety of ingredients, serve to produce from their volatile ingredients illuminating gas and coal oils. These two subjects will be treated in distinct chapters, and that upon the oils may properly include an account of the wells of natural oil recently developed in the north-west part of Pennsylvania, and in neighboring districts in New York and Ohio, as also in Virginia and Kentucky.

CHAPTER X.

ILLUMINATING GAS.

THE supply of artificial light in abundance and at little cost is one of the most important benefits which science and mechanics can confer. It contributes not merely to physical comfort and luxurious living, but supplies the means to multitudes of obtaining instruction during those hours after the cessation of their daily labors, which are not required for sleep, and which among the poor have in great measure been spent in darkness, on account of the expense of artificial light. At the present day it is not unusual, in the less cultivated portions of the country, to see a farmer's family at night gathered around a blazing fire, and some among them seeking by its fitful light to extract the news from a public journal, or perhaps conning their school tasks, and making some attempts at writing or ciphering; and when the hour to retire has come, the younger members disappear in the dark, and the more honored are favored with a home-made tallow candle, just sufficient for this use, and endurable only to those who are unaccustomed to a more cleanly and efficient method of illumination. With the advance of cultivation and learning, the demand for better light has increased the more rapidly it has been met. The sea has been almost exhausted of whales for furnishing supplies of oil. The pork of the West has been largely converted by new chemical processes into lard oil and the hard stearine for candles; and numerous preparations of spirits of turpentine, under the name of camphene and burning fluid, have been devised and largely introduced with ingenious lamps contrived to secure the excellent light they furnish, with the least possible risk of the awful explosions to which these fluids are liable when their vapor comes in contact with fire. The bituminous coals have been made to give up their volatile portions—by one process to afford an illuminating gas, and by another to produce burning oils; and the earth itself is bored by deep wells to exhaust the newly-found supplies of oil gathered beneath the surface at unknown periods by natural processes of distillation. The resinous products of the pine tree are applied to the production of oil and gas for the same purposes; and peat, wood, and other combustible bodies—even water itself—are all resorted to as sources from which the cry for "more light" shall be satisfied.

The distillation of carbonaceous and bituminous substances to obtain an illuminating gas is a process, the practical application of which hardly dates back of the present century. The escape of inflammable gases from the earth, in different parts of the world, had been observed, and the phenomenon had been applied to superstitious ceremonials, especially at Bakoo on the shores of the Caspian. The Chinese are said to have applied such natural jets of gas to purposes of both illumination and heating; but the first attempts to light buildings by gas distilled from bituminous coal were made about the year 1798 by Mr. Murdock in the manufactory of Messrs. Boulton and Watt, at Soho, England, and about the same time in France by a Frenchman named Le Bow. The London and Westminster Chartered Gas Light and Coke Company was incorporated in 1810, and Westminster bridge was lighted with gas, Dec. 31, 1813. The process was introduced into this country about the year 1821. Some attempts had been made at an earlier date, as in Baltimore according to some statements in 1816, and in New York four years before this. In the New York *News* of August 15, 1859, is an account of the efforts made by Mr. David Melville of that city to establish the use of coal gas in 1812. He lighted his own house with it, and then a factory at Pawtucket. He also succeeded in having it applied to one of the lighthouses on the coast of Rhode Island, and for one year its use was continued with success. But on account of the disturbed state of the times and the prejudices against the use of a new material, the enterprise fell through. In 1822 the manufacture of gas was undertaken in Boston; and the next year the New York Gas Light Company was incorporated with a capital of $1,000,000. The works, however, were not completed and in operation until 1827. Another company, called the Manhattan Gas Light Company, was incorporated in 1830 with a capital of $500,000, which has since been increased to $4,000,000. Such were the beginnings of this branch of manufacture, which has of late rapidly extended itself throughout all the cities and many of the towns of the United States, having works in operation representing a capital of

more than $35,000,000, which in 1859 were owned by 237 companies. Some of these works are among the largest and most expensive manufacturing establishments of any kind in the country, including besides the apparatus employed for generating and holding the gas, the pipes extending throughout the cities for the supply of consumers. In New York city the pipes belonging to the Manhattan Gas Light Company, of diameters varying from 3 to 20 inches, amounted in 1858 to 207 miles in length; and those of the New York Gas Light Company, of diameters from 4 to 18 inches, amounted to 138 miles. The former company supplies that portion of the city which lies above Grand street as far as Seventy-ninth street, and the latter that portion below Grand street.

Within the last few years the use of gas has increased with great rapidity throughout the cities and towns of the United States, till the number of companies in operation in the year 1860 amounted to 381, according to the statistics published in July of that year, in the *American Gas Light Journal*. These companies represented a capital of $47,911,215; and it is since ascertained that this sum must be considerably increased by adding to the list over 50 other companies from which no returns had then been received. The interest it appears must already rank among the important branches of industry of the country. For much of the statistical information on this subject we are chiefly indebted to the records collected for the journal above named. The first table below will serve to present some idea of the extent of the larger establishments, and the range in the cost of gas, which varies according to the cost of the coal employed, the scale of the operations, etc. The lowest price paid for gas is at Pittsburg, Pennsylvania, $1.50 per 1000 cubic feet, the bituminous coal employed costing only $1.25 per ton. In many of the smaller towns $7 is the price, which is the maximum on the Atlantic side of the continent.

The second table gives the aggregate number of gas works in the several states, amount of capital invested, etc.

SOME OF THE PRINCIPAL GAS LIGHT COMPANIES IN THE UNITED STATES.

Chartered.	Localities.	Chartered capital.	Approximate annual production. Cubic feet.	Prices to private consumers per 1000 cubic feet.	Average cost of coal used per ton.
1830,	Manhattan, N. Y.	$4,000,000	725,321,000	$2 50	$6 50 to $11 00
1823,	New York, N. Y.	1,000,000	430,000,000	2 50	.. ..
1825,	Brooklyn, N. Y.	2,000,000	163,000,000	2 50	7 28 to 8 15
1859,	Citizens' Co., Brooklyn.	1,000,000	..	2 50	.. ..
1841,	Philadelphia	3,000,000	432,000,000	2 25	6 50 ..
	Northern Liberties	400,000	70,000,000	2 50	6 29 ..
1822,	Boston, Mass.	1,000,000	200,000,000	2 50	5 00 to 12 00
1851,	Cincinnati, Ohio	1,600,000	96,708,900	2 50	3 40 ..
1849,	Chicago, Ill.	1,300,000	86,250,810	3 50	5 78 ..
1846,	Charleston, S. C.	723,800	..	4 00	.. ..
1839,	St. Louis, Mo.	600,000	74,500,000	3 50	7 50 ..
1835,	Pittsburg, Penn.	300,000	54,720,000	1 50	1 25 ..
1848,	Providence, R. I.	1,000,000	41,437,883	3 00	7 20 ..
1845,	Albany, N. Y.	250,000	40,250,000	3 00	6 75 to 8 00
1838,	Louisville, Ky.	600,000	33,750,000	2 70	.. ..
1850,	Williamsburg, N. Y.	500,000	33,493,082	3 50	6 25 to 9 50
1848,	Troy, N. Y.	200,000	28,000,000	3 60	7 20 ..
1851,	Richmond, Va.	341,975	27,000,000	3 00	4 15 ..
1852,	Rochester, N. Y.	200,000	25,000,000	2 50	5 38 ..
1849,	Lowell, Mass.	200,000	21,000,000	3 25	6 50 ..
1848,	Cleveland, Ohio	200,000	20,000,000	3 00	4 25 ..
1849,	Detroit, Mich.	500,000	20,000,000	3 50	5 00 ..
1853,	Jersey City, N. J.	300,000	19,234,000	3 00	7 89 ..
	Milwaukee, Wis.	400,009	19,049,560	3 50	6 00 ..
1849,	Hartford, Conn.	200,000	15,000,000	3 00	8 68 ..
1849,	Portland, Maine	250,000	..	3 50	.. ..
1857,	Columbia, California	50,000	..	10 00	.. ..
1852,	San Francisco, "	1,000,000	..	8 00	.. ..
1858,	Marysville, "	50,000	..	12 50	.. ..
	Stockton, "	50,000	..	10 00	.. ..
1857,	Sacramento, "	500,000	..	10 00	.. ..

TOTAL OF GAS COMPANIES IN THE UNITED STATES FROM RETURNS OF JULY, 1860.

State.	Companies.	Capital.	Coal gas.	Average price.	Rosin gas.	Average price.
Alabama	3	$320,000	3	$5 16	..	..
Arkansas	None.	..	..	..	..	..
California	9	1,790,000	9	10 05	..	..
Connecticut	14	953,000	14	3 83	..	..
Delaware	3	244,300	3	3 50	..	..
District of Columbia	1	500,000	1	3 25	..	..
Florida	1	30,000	1	7 00	..	..
Georgia	6	559,160	4	4 68	2	$6 50
Illinois	13	2,595,000	13	3 91	..	..
Indiana	7	605,000	7	3 97	..	..
Iowa	5	355,000	5	4 40	..	..
Kansas	1	200,000	1	5 00	..	..
Kentucky	5	905,000	5	4 04	..	..
Louisiana	2	1,540,000	2	4 50	..	..
Maine	10	905,300	9	3 90	1	7 00
Maryland	6	780,000	3	3 49	3	6 60
Massachusetts	49	4,759,000	45	3 43	4	6 37
Michigan	8	745,000	8	3 78	..	..
Minnesota	1	200,000	1	6 00	..	..
Mississippi	4	212,000	4	4 75	..	..
Missouri	4	775,000	4	4 50	..	..
New Hampshire	9	425,000	9	3 98	..	..
New Jersey	19	1,849,610	17	3 72	2	6 50
New York	71	12,780,250	61	3 70	10	6 70
North Carolina	8	187,000	..	..	8	5 93
Ohio	30	3,338,600	29	3 85	1	7 00
Oregon	1	50,000	1	8 00	..	..
Pennsylvania	48	5,657,700	48	3 55	..	..
Rhode Island	7	1,344,000	6	3 58	1	7 00
South Carolina	2	767,800	2	5 00	..	..
Tennessee	4	663,000	4	4 00	..	..
Texas	3	225,000	3	6 33	..	..
Vermont	8	216,000	6	4 25	2	6 50
Virginia	11	1,030,000	10	3 68	1	7 00
Wisconsin	8	778,500	8	4 44	..	..
Grand total	381	$47,911,215	346	..	35	..

The preparation of illuminating gas from bituminous coal, wood, rosin, and other bodies of organic nature, is a chemical process, too complicated to be very fully treated in this place. When such bodies are introduced into a retort and subjected to strong heat, the elements of which they consist, as carbon, hydrogen, oxygen, and nitrogen, resolve themselves into a great variety of compounds, and escape (with the exception of a fixed carbonaceous residue of charcoal or of coke) through the neck of the retort in the form of gas or vapors, some of the latter of which condense on cooling into liquids and solids. These compounds are rendered more complicated by appropriating the elements of air and moisture that may be present in the retort or in the crude material, and also of the foreign substances or impurities contained in the latter. In processes of this kind, the products vary greatly in their character and relative proportions according to the degree of heat employed, and the rapidity with which the operation is conducted. The object in this special distillation is to obtain the largest proportion of the gases richest in carbon, particularly that known as olefiant gas, which consists of 86 parts by weight of carbon and 14 of hydrogen, represented by the formula $C_4 H_4$. This and some other gaseous hydrocarbons of similar composition, or even containing a much larger amount of carbon in the same volume, and hence having a correspondingly greater illuminating capacity, it is found, are produced most freely from carbonaceous substances which contain a large proportion of hydrogen compared with that of oxygen. Many of the common bituminous coals contain about 5·5 per cent. each of hydrogen and oxygen, the rest being carbon. Boghead cannel of Scotland contains 11 per cent. of hydrogen and 6·7 of oxygen; rosin 10 per cent. hydrogen and 10·6 oxygen; wood 5·5 hydrogen and 44·5 oxygen. Of such compounds the cannel

yields the richest gas and in largest quantity. Still, as will be more fully explained hereafter, the process may be so conducted as to obtain chiefly liquid instead of gaseous products. With the olefiant gas and the others of similar composition, a number of other gases also appear, some of which seem to be essential for producing the effect required in illuminating gas, though they do not themselves afford light by their combustion. Their part is rather like that of nitrogen in the atmosphere, to moderate the intensity of the more active agent of the mixture. Such are the light carburetted hydrogen, carbonic oxide, and hydrogen, all of which are inflammable, but possess little or no illuminating power. The first named contains in an equal volume only half as much carbon as olefiant gas, its composition being represented by the formula C_2 H_4, and if its proportion is too great for the purpose it serves as a diluent, the quality of the gas is impaired, and must be corrected by the use of richer material or increased care in the process.

The light produced by the combustion of gas is variable, not only according to the quality of the gas, but also according to the manner in which it is burned. If its elements undergo the chemical changes which constitute combustion simultaneously, the hydrogen combining with the oxygen of the air to form aqueous vapor, and the carbon with oxygen to produce carbonic acid, no yellow flame appears, but instead of this, a pale blue flame like that of hydrogen alone. Such an effect is produced when air is thoroughly intermixed with the gas as it passes through a tube to the jet where it is ignited. But if the conditions of the combustion are such that the hydrogen burns first and appropriates the oxygen in contact with the gas, the particles of carbon are brought to an incandescent state and produce the yellow light before they reach the oxygen with which they combine. The particles may even be arrested while *in transitu* and be deposited upon a cold surface in the form of soot. The greatest heat is produced with the most thorough mode of combustion and the appearance of the pale blue flame; and lamps designed to give great heat are now in general use among chemists, in which gas is burned in this manner. When the air is impelled by a bellows they even produce an intensity of heat sufficient for many crucible operations.

If too much carbon be present a part of it escapes unconsumed and produces a smoky flame, hence the necessity of the diluents or gases deficient in carbon for neutralizing the too large proportion of those gases richest in carbon. The noxious compounds in illuminating gas, and which should be as far as possible extracted from it before it is delivered for consumption, are the sulphurous ingredients formed by the combination of the sulphur of the iron pyrites commonly present in bituminous coals with the carbon, and with the hydrogen and the ammoniacal products. They are the highly offensive sulphurets of carbon, the sulphuretted hydrogen, etc. Carbonic acid, nitrogen, oxygen, carbonate of ammonia and aqueous vapors are to be regarded as foreign substances, though always present to some extent in the gas.

The liquids generated by the distillation mostly condense in two layers on cooling, the upper an aqueous fluid, rendered strongly alkaline by the ammoniacal compounds in solution; and the lower a black tarry mixture commonly known as coal tar, which is composed of more than a dozen different oily hydrocarbons, as benzole, tuluole, etc., and contain in solution the solid oily compounds of carbon and hydrogen, as naphthaline, para-naphthaline, and several others. Many of these are likely to prove of considerable practical importance. Benzole is a highly volatile fluid, a powerful solvent of the resins, india-rubber, gutta percha, greasy matters, etc. A most beautiful light is produced by the flame of benzole mixed with due proportions of common air, and the mixture is effected by passing a current of air through the fluid, the vapor of which it takes up and carries along with it. The difficulty attending this application is the condensation of the benzole and its separation from the air at temperatures below 50°. Above 70° too much vapor is taken up, and the effect is a smoky flame. In Europe much attention has been directed to the separation of the more hidden products of coal tar; and among these the following are enumerated in a statement exemplifying the rapid increase in the value of these products as they are obtained by more extended researches. Benzole worth about 25 cents a pound; nitro-benzole, a substance having the odor and taste of bitter almonds and used as a flavoring, worth, crude, 70 cents, or refined, $1.50 per pound. The or-

dinary aniline dye for producing the mauve color, $4.50 to $8 per pound, and the pure aniline violet in powder $240 to $325 per pound, or about its weight in gold.

Gas works established in cities and towns are commonly built in places where the property and buildings around are least likely to be injured by the escape of the products, and rather upon a low than a high level, for the reason that the gas on account of its lightness compared with the atmospheric air ascends more freely than it descends to its points of communication with the external air. The works consist of the apparatus for distilling the coal and receiving the products of the distillation, that for purifying the gas, and that for conveying it to the places where it is consumed, and there measuring the quantities supplied to each customer. The retorts in general use are either of cast iron or of fire clay. The latter are a late improvement highly recommended, and introduced at the present time into a few of the gas works. Various forms have been tried; the most approved are of D shape, 7 to 9 feet long, 1 or 2 feet wide, and 12 or 15 inches high. They are set in the furnace stacks, commonly two on the same horizontal plane, two more over these, and a fifth at the top. A single furnace fire below is sufficient for heating them, and the capacity of the works is increased by multiplying these fires along the length of the stacks. Sometimes the stacks are made double, so as to take two retorts set end to end, each opening on opposite sides of the stack. In place of two retorts a single long one has been substituted, passing entirely through and having at each end an opening for charging and discharging. In large establishments as many as 600 or more retorts may be set, all of which may be kept employed in the winter season, when the consumption of gas is largest. The outer end of each retort projects a little way in front of the wall of the furnace, and is provided with a movable mouth-piece covering the entire end, which may be readily removed for admitting the charge of coal. Upon the top of this projecting end or neck stands the cast-iron pipe of about 4 inches in diameter, called the stand pipe, through which the volatile products pass from the retort. It rises a few feet, then curves over back, and passes down into a long horizontal pipe of large diameter, which is laid upon the outer edge of the brick-work, and extends the whole length of the furnace stacks. This is called the hydraulic main, and into it all the volatile products from the retorts beneath are discharged. It is kept about half filled with water or the liquid tarry matters, and the dip pipes terminate about three inches below this fluid surface. By this arrangement the retorts are kept entirely independent of each other, while their products all meet in one receptacle.

In manufacturing gas it is found necessary to introduce the charge into the retorts already at a full red heat, and bring it as rapidly as possible to the high temperature required for producing the richest gaseous hydrocarbons. A low and slowly increasing heat causes the ingredients of the charge to form a large proportion of liquid and oily substances, and little gas. It is only while the coal is approaching a vivid red heat that the best gaseous mixtures are obtained; and even these are deteriorated by change in the composition of the olefiant and other rich gases of which they are in part composed, if the mixture is exposed to too high temperature, or remains in contact with red hot surfaces of iron. The duration of the charge used formerly to be from 8 to 10 hours; but from the observations of the qualities of the gases evolved at different stages of the process, it has gradually been reduced to 4 to 6 hours, varying according to the character of the coal employed. The richest gases are obtained in the first hour, and after this the proportional quantity per hour steadily diminishes at the same time that the quality gradually deteriorates. The temptation, however, to obtain the largest amount of a commodity which is sold only by measure, and to consumers who have no means of assuring themselves of its real quality, no doubt often leads to extending the operation to the separation of gaseous mixtures having very little illuminating power. The manufacturers knowing their materials, and checking their operations by regular photometrical tests, can control the quality of the product as they see fit.

In order that the least loss may be incurred in bringing the charge up to the proper temperature, the retorts are kept at a full red heat; and when ready for a new charge the mouth-piece is partially removed, and the gas that escapes is ignited. When the danger of explosion by sudden admission of air has passed the lid is removed, and the red hot coke is raked out and quenched with water.

The new charge is then introduced by means of a long iron scoop bent up at the sides, which is pushed into the retort, and being turned over, discharges its contents. The mouth-piece is then replaced, and tightly secured with a luting of clay or lime. It is obvious that the more perfectly the coal is freed from moisture, the better must be the gas; and if it were also first somewhat heated, the result would be still more satisfactory. The coals employed at the different gas works of the United States are generally mixtures of the caking coals of the interior, or of those of Richmond, Virginia, and of Nova Scotia, with cannel coal, which for the cities near the coast is imported from Great Britain, and for those in the interior is obtained from the mines of this coal in western Virginia and in Kentucky. The larger the proportion of cannel, the better should be the gas, under the same method of manufacture. In the works in New York city, the proportion of cannel is generally from one third to one fourth of the whole. Other establishments generally use a less proportion of it. The amount of gas it may produce varies with the kind of cannel from 9500 cubic feet to the ton to 15,000 cubic feet. The last is the yield of the Boghead cannel. In general, the greater the yield the better also is the quality of the gas, as is indicated by its increased specific gravity, that of the cannel last named being .752, while the gas from other cannels yielding about 10,000 cubic feet may not exceed .500. The best Newcastle coals are not inferior, either in the amount or quality of the gas they afford, to most of the cannels. They produce about 12,000 cubic feet of gas to the ton, and of specific gravity sometimes exceeding .550 or even .600. The specific gravity is not depended upon as a certain test of the quality of the gas, the density of which may be increased by presence of impure heavy gases, or even of atmospheric air; but it is resorted to only as an indication in the absence of more exact tests.

The coke obtained from the retorts, amounting to about 40 bushels to the ton of coals, furnishes all the fuel required for the fires beneath, and three times as much more, which is sold for fuel. As the volatile products pass through the hydraulic main, the principal portions of the oily and ammoniacal compounds are deposited in it; but some of these pass on in vapors, and would, if not separated, cause obstructions in the pipes in which they might condense in liquids and solids. They are consequently passed through a succession of tall iron pipes standing in the open air, and sometimes kept cool by water trickling down their outside. A pipe from the bottom of each pair conveys the condensed tar and ammonia into a cistern in the ground. To still further separate the condensable portions, the gas at some works is next passed into the bottom of a tower filled with bricks, stones, etc., among the interstices of which it finds its way up, at the same time that water constantly sprinkled on the top is working down and keeping the whole cool. The water washes away the remaining ammonia; but it is to be feared that it also removes some of the richest hydrocarbons, and the use of the wet scrubber, as it is called, is already abandoned at some of the gas works for similar methods of condensing, except that the water is dispensed with. The gas makes its exit from the top of the scrubber; and its passage being already somewhat impeded so as to throw considerable pressure back into the retorts, thus effecting chemical changes in the gas, which impair its quality, it is found necessary to introduce a revolving exhauster, which takes off this pressure, and at the same time propels the gas forward into the succeeding apparatus. This is first a purifier, the object of which is to arrest the carbonic acid and sulphurous gases. Dry quicklime, and also the solution of this in water, known as milk of lime, have the property of absorbing these gases as they are made to pass among the particles of the one spread upon shelves, or interspersed among a porous substance such as dry moss; or to bubble up through the aqueous solution. The lime as it becomes saturated with the impure gases is replaced with fresh portions.

The cleansing process is now complete, and the gas is in proper condition to be delivered to the consumer. It must first, however, be measured, that a record may be kept of the quantity produced, and it is next conducted into the great gas-holders in which it is stored. The measurement is effected by means of a large station meter, constructed on the principle of the small service-meters, with one of which each consumer is supplied. A revolving drum with four compartments of equal capacity is made to rotate in a tight box by the gas entering and filling one of these compartments after another.

Their capacity being known, and the number of revolutions being recorded by a train of wheel-work outside the box, the quantity of gas which passes through is exactly indicated. The largest meters pass about 650 cubic feet by one revolution of the drum, or about 70,000 cubic feet in an hour.

The gas-holders are the large cylindrical vessels of plate iron, the most conspicuous objects at the gas works. Each one is set with its open end down, and immersed in a cistern of water of diameter a little exceeding its own. It is buoyed up by the water, and also counterbalanced by weights passing over pulleys. The gas admitted under the inverted cylinder lifts this up, and fills all the portion above the water. The weight of the cylinder when the influx is shut off, and the discharge pipes are opened presses the gas out and through the mains to the points where it is consumed. The gas-holders of the largest works are of immense size. In Philadelphia, there is one 160 feet in diameter and 95 feet high, holding 1,800,000 cubic feet of gas. Even this is exceeded by one at the Imperial Gas Company's works, London, which is 201 feet in diameter, 80 feet high, and of the capacity of 2,500,000 cubic feet. This cost upward of $200,000; and contains 1500 tons of iron, 5000 cubic feet of stone work, and 2,000,000 bricks. No advantage is gained in a single structure of this immense size over several smaller ones. On the contrary, this involves heavy expenditures to protect them against the force of the wind, and render them manageable. Those of great height are made in sections, which shut one within another in descending, like the parts of a telescope. As each section is lifted in turn out of the water, its lower edge, which is turned up in an outward direction, forming an annular cup, includes a portion of water, into which the upper edge of the next lower section catches, being turned over inward for this purpose. A gas-tight joint between the two sections is thus formed.

To insure uniformity of pressure, as the gas enters the mains it is first made to pass through the apparatus called a governor, in which, according to the force or slowness with which it moves, it causes a valve to rise and partially close an aperture within the machine through which the gas flows, or to descend and open this aperture. The increase of pressure as the gas is carried to higher levels, amounting to one fifth of an inch of water in every 30 feet, renders it important in hilly towns to have governors upon different levels. In high buildings a very sensible difference is perceived in the force with which the gas issues from the burners on the different stories. This involves a waste of gas where the pressure is great, for under such conditions a considerable portion of that consumed adds little to the illuminating effect. Various governors or regulators have been devised for the use of consumers with a view of producing an increase of light with reduced consumption of gas; and when judiciously applied, some of them, as Kidder's and Stirling's, have proved very successful. The latter has been introduced into some of the public buildings of New York city, controlled by the Street Department, and according to the report of the Street Commissioner, the saving has been in many instances very remarkable.

Each consumer of gas is supplied with a meter, which is under the control of the gas company; and from its indications the amount furnished is determined by inspection every month.

Though in the use of gas the consumer is in a great measure dependent on the manufacturer as regards the economy of the light, there are several points, by giving personal attention to which, he may more fully realize the saving it affords. In the first place, he must be aware that every one employing this source of light uses it more freely than that derived from lamps and candles. It is enjoyed with so little trouble and apparent cost, that much more light is soon regarded essential, than was perfectly satisfactory under the old methods of producing it. He should next see that the area of the delivery pipe bears such proportion to the quantity usually required, that there is no undue pressure upon the burners, as is evident when the gas "blows" through them as it burns. This should be checked by shutting off a part of the supply by means of the stop-cock at the meter; and this should be looked to after every visit of the gas man to the meter. The regulator also is intended to remedy this over supply, but it may still be necessary to keep part of the gas turned off, and by so doing the regulator may be dispensed with. Attention should next be directed to the burners, that those of largest size, such as consume with the ordinary pressure six feet or more of gas an hour, should be placed only where the greatest quantity of light is

required, and that burners of four feet, three feet, two feet, or even one foot an hour, be placed where the light they give will be sufficient. The burners called Scotch tips, giving what is called the fish-tail flame, are in common use, but a great variety of others have been contrived, and some of them are highly recommended for affording more light with the same amount of gas. All, however, are liable to become foul after a time, and should be occasionally cleaned or replaced. The iron of which they are made is corroded by the ingredients of the gas, especially when not in use, and air entering its elements form acid compounds with those of the gas which remain in the open portion of the pipe. The argand burner is recommended for the powerful and steady light it gives, but it is far from being economical, and moreover produces great heat. For a steady light Gleason's "American gas-burner" combines the advantages of brilliant light, steadiness of flame, and moderate consumption.

The quality of gas is determined either by analysis, or more conveniently by testing with the photometer its comparative capacity of producing light. The standard adopted for comparison is spermaceti candles, each one burning 120 grains in an hour. An argand burner consuming five feet of gas an hour (the quantity carefully proved by the meter) is used in making the trial; and the number of candles required to produce an equal amount of light indicates the quality of the gas. At the points of consumption this is sometimes inferior to that of the gas at the works before it enters the gas-holders and passes through the mains; but in very cold weather, by the condensation of the richest hydrocarbon vapor in the pipes, the gas that reaches the burners is poorer than that which left the works. Consequently these facts should be taken into consideration in estimating the quality of gas furnished by any establishment. Again, after a period of excessive cold weather, when the gas has burned dimly by the condensation of its best portions in the pipes—it may be to the extent at times of obstructing the flow through them—and with the return of milder weather the vapors are released and mix with the new gas, they sometimes so overburden this with an undue proportion of the richest compounds, that with the ordinary burners the gas cannot be consumed, and the result is a smoky flame, of which the consumers make great complaint, believing it to be caused by inferior gas. Such are some of the causes, over which the manufacturers have no control, that involve more or less irregularity in the quality of the gas supplied.

The gas produced at different works is of various qualities. That of the Manhattan Gas Light Company is rated at sixteen candles, and is probably as good as any furnished in our cities. It is tested daily with the photometer at their office, at the corner of Irving Place and Fifteenth street, New York. In England, the gas of the London works varies from eleven to eighteen candles. That of Liverpool is much better, sometimes being equal to twenty-two candles.

Other materials than coal have been applied to some extent in the United States for producing gas, chiefly for small supplies for single buildings. The most successful of these processes is that with rosin oil. The apparatus is exceedingly simple, and is placed in an apartment in an out-building. It consists of a stove containing a chamber in the top, into which the rosin oil is allowed to drop slowly. It is decomposed by the heat of the surface upon which it falls, and the gaseous products pass immediately through the pipes into the gas-holder, whence they are distributed as at the large gas works. The supply for a week may be made in less than an hour with very little attention from the person in charge. The gas is superior to that from coal, and the expense, not reckoning the cost of the gas-holder and the apparatus, is less than the price ordinarily paid for gas.

In Philadelphia wood has been successfully used at the Market street bridge works. Six retorts have been kept in operation with it for some time, and the yield and quality of the gas have proved very satisfactory. As in the use of coal, it is found necessary to charge the material into retorts already at a high heat, otherwise the gaseous products have little illuminating power. Gas thus made from pine wood has been found to contain 10.57 per cent. of olefiant gas, and that from oak 6.46 per cent.

Hydrocarbon Gas.—What is known as the hydrocarbon or water gas manufacture was introduced into Philadelphia in 1858, and according to the published reports, its application to lighting a portion of the Girard House in that city, proved for several months perfectly satisfactory. It was introduced into the town of Aurora, Indiana, in January, 1861, and according to the statements pub-

lished in the Cincinnati *Daily Commercial*, the operation had been very successful. The light is described as very brilliant, and the gas almost free from odor. The process appears to be similar to that of Mr. White, of Manchester, England, which consists in the generation of the non-illuminating gases by the action of steam upon charcoal highly heated in a retort, the aqueous vapor being thereby decomposed, and various gaseous compounds produced by its hydrogen and oxygen combining with the carbon of the charcoal. If the operation is properly conducted these compounds should be almost entirely carbonic oxide and free hydrogen; if carbonic acid is produced, as it may well be, even to the extent of one per cent., it may involve the expense of purification by means of a lime purifier. These gases are immediately passed through another retort, in which the illuminating gases are generated, and mixing with them the whole is immediately swept forward out of the reach of the high decomposing temperature. The material employed for furnishing the illuminating gas is either rosin or rosin oil gadually dropped into the heated retort; and it is stated that various other carbonaceous substances, as the tar from the gas works and cheap greasy compounds, may be economically applied.

Although this method of producing gas has been highly recommended by eminent English authorities, especially by Dr. Frankland, an account of whose experiments and conclusions is given in the recent edition of Ure's Dictionary (London, 1860), vol. i., p. 778, it has not been adopted by gas companies, whose first interest it would be to avail themselves of such improvements, and it is reasonable to suppose there are some insuperable objections to it. Indeed, in the last edition of Clegg's "Treatise upon the Manufacture and Use of Gas," the subject is passed by with scarcely any notice, although it had been in the previous edition treated in detail and with commendation. In the English *Gas Journal*, it is decidedly condemned. No analyses of the gas thus produced in this country have ever been published, nor any reports of photometrical experiments that might establish its light-giving capacity. As the subject has attracted so much interest of late, and has given rise to extravagant expectations of cheap production of gas, it is very desirable that such trials and reports should be made by some competent chemist. In Philadelphia, the subject has given rise to a newspaper controversy, and the publications were embodied, in 1860, in a pamphlet entitled "The Water Gas Correspondence." They contained nothing, however, to determine the real merits of the gas.

GAS FOR STEAMBOATS AND RAILROAD CARS.—Several methods have recently been put in practice of furnishing gas for the convenience of passengers in steam vessels, or upon railroads. One plan is to place in the boats or under the cars large cases of sheet iron, each one provided with a diaphragm or partition of india-rubber across its upper portion. A connection being made between the receptacle under the diaphragm and the street main, the gas fills this portion of the case and the connection is then shut off. When required for use, the gas is forced out by the pressure of air uniformly applied upon the upper surface of the india-rubber sheet by means of a meter running by clock work. This method has so far been successful; but danger is apprehended by some that atmospheric air may find its way through the flexible sheets, all of which are more or less permeable when used to separate different gaseous compounds, and that an explosive mixture may thus be introduced. By another plan of a New York company, the gas by means of force pumps is compressed into strong cylindrical gas-holders made like the boilers of steam engines. The gas is thus made to occupy a diminished space in proportion to the pressure used, that of 20 atmospheres placing 1000 cubic feet of gas in 50 feet space. In Jersey City, where this method has been applied to furnishing gas for railroad cars, the pressure employed is about 450 lbs. upon the square inch. Under this pressure the gas is conveyed through pipes to the points where the cars receive from them their supplies. The gas by its elasticity presses through the burners, and uniformity of discharge while this force is constantly diminishing is secured by a governor or regulator constructed on the principle already described.

GAS FOR FUEL.—Besides its use for producing light, gas has lately been applied to other domestic purposes for the sake of the heat it can be made to afford in burning. It was thus first used by chemists, and mechanics, as bookbinders, then applied it in suitable stoves to the heating of such tools as they required of a high temperature. After

this stoves were contrived on different plans in which various culinary operations might be conducted, and some also for warming rooms. Though it would appear to be an expensive fuel, it has been found for many purposes, in which only a certain amount of heat is required, and this for a short time, not merely exceedingly convenient, but even economical. No more need be consumed than is required to effect the desired purpose, and it is moreover applied directly to the object to be heated with little dispersion or waste of heat. But for warming rooms, it is objectionable, not only on account of its cost, but also from its vitiating the atmosphere by the large amount of the noxious gases produced by its combustion. If these are conveyed away by ventilating flues, they carry with them a considerable portion of the caloric set free. No doubt when gas is afforded at lower rates, means will be devised of applying it more advantageously to this purpose.

CHAPTER XI.

HYDROCARBON OR COAL OILS.

NOTWITHSTANDING the substitution in the cities and most of the towns of considerable size throughout the country of gas for oils, the demand for the latter has increased much faster than the supply, as is shown by the price for sperm oil being now more than three times what it was in 1843, when it brought about fifty-five cents per gallon. Besides its use for illuminating purposes, the consumption of oil is enormous for lubricating machinery. The railroads and steamboats, and the increasing numbers of large factories, demand such quantities of it that all the ordinary sources of supply were overtasked, and the whaling business formerly so prosperous in New England, has fallen off in the face of advancing prices, or been forced to gather itself in fewer centres, where by concentration of its operations the business could be conducted with the greatest economy. From many seaports of New England this business has quite disappeared, and the following changes in others are reported to have taken place between the years 1843 and 1859. In the former period New Bedford had 214 whale ships, and in 1859 the number had increased to 316. In New London, Conn., the number had increased from 45 to 56, and in Mattapoiset from 11 to 19. In other towns the number of ships had fallen off as follows: Nantucket, to 33 from 85; Sag Harbor, to 20 from 43; Warren, R. I., to 15 from 21, etc. At Fairhaven, 46 ships were owned at both periods. The manufacture of lard oil, which of late years has been extensively carried on in the Western states, failed to meet the increasing demands, when at last attention began to be directed to the extraction of oils from the bituminous coals and shales, by processes of recent introduction in France and England. The success attained by Mr. James Young, of Glasgow, in his treatment of the "Torbane Hill mineral," or Boghead cannel of Scotland, served more than any thing else to give encouragement to this enterprise. In 1854, according to the testimony of this practical chemist, in a lawsuit in London, he was producing about 8000 gallons a week of an oil he called paraffine oil, which sold for 5s. a gallon, the sales amounting in all to about $500,000 per annum, of which the greater portion was profit. Operations of a similar character had for some time previously been conducted upon a large scale at Autun, Department of the Saone-and Loire, in France; the materials employed being highly bituminous shales, probably not essentially different from the Torbane Hill mineral, except in producing much less oil to the ton.

The first factory for making coal oil in the United States was established on Newtown Creek, Long Island, opposite New York city, and commenced operations in June, 1854. This was known as the Kerosene Oil Works, and was designed to work the Boghead cannel, or coal of similar character from the province of New Brunswick, or from the West, by the patented process of Mr. Young. In Kentucky, Ohio, Virginia, and Pennsylvania cannel coals were found of suitable qualities for this manufacture; and in 1856 the Breckenridge Coal Oil Works were in successful operation at Cloverport, on the Ohio river, in Breckenridge county, Ky. The same year a factory was built in Perry county, Ohio, by Messrs. Dillie and Robinson, and others rapidly sprung up in the vicinity of Newark, which soon became an important centre of this new business. In 1858, several large factories were built in New England, one in Boston, and one in Portland, Maine. The following is an incomplete list of factories which have been put in operation, not including some which have been destroyed by fire:—

TABLE OF THE COAL OIL WORKS OF THE UNITED STATES.

State.	Town or county.	Name of works.	No. of factories.	Daily capacity in 1860. Gallons.
Maine,	Portland	Portland Company	1	4000
Massachusetts,	Boston	Downer Kerosene Co	1	4000
"	"	Page & Co	1	600
"	"	Suffolk Company	1	300
"	"	Pinkham	1	..
"	"	Peasley	1	..
"	East Cambridge	E. Cambridge Company	1	800
"	New Bedford	New Bedford Company	1	300
Connecticut,	Hartford	Hartford Company	1	200
"	Stamford	Stamford Company	1	..
New York,	Newtown Creek, L. I.	Kerosene Oil Company	1	4000
"	Hunter's Point, L. I.	Luther Atwood	1	2000
"	"	Carbon Company	1	300
"	South Brooklyn	Empire State Company	1	300
"	"	Franklin Company	1	500
"	Williamsburgh	Long Island Company	1	..
"	"	Knickerbocker Company	1	..
"	"	Fountain Oil Co.	1	400
"	Harlem	Beloni & Co	1	50
"	"	Excelsior Company	1	..
Pennsylvania,	Darlington, Beaver Co	Anderson & Co	1	..
"	" "		1	..
"	Kiskiminitas	Aladdin Company	1	..
"	"	Lucesco Company	1	2000
"	Freeport, Armstrong Co	North American Company	1	
"	New Galilee	New Galilee	1	..
"	Enon Valley	Enon Valley Company	1	..
Ohio,	E. Palestine, Columbiana Co	Palestine Company	1	..
"	Canfield, Mahoning Co	Cornell & Company	1	..
"	" "	Sherwood	1	..
"	" "	Phœnix	1	..
"	" "	Mystic	1	..
"	" "	Canfield	1	..
"	Cleveland	Dean	1	..
"	Zanesville	Brooks	1	..
"	"	Cox	1	..
"	Newark, Licking Co	Great Western	1	500
"	" "	Three others	3	..
"	Steubenville, Jefferson Co		2	..
"	Coshocton Co		7	..
"	Columbus, Franklin Co		1	..
"	Cincinnati	Grasseli	1	..
"	"	Western Company	1	..
"	"	Phœnix Company	1	..
"	Perry Co	Robinson & Co	1	..
Virginia,	Kanawha region	Falling Rock Company	1	..
"	" "	Forest Hill Company	1	..
"	" "	Greers	1	..
"	" "	Great Kanawha Company	1	..
"	" "	Staunton Company	1	..
"	" "	Atlantic Company	1	..
"	" "	Union Company	1	..
"	" "	K. C. C. M. and O. M. Company	1	..
"	Preston Co	Preston Company	1	..
"	Monongalia Co	White Bay Company	1	..
"	Ritchie Co	Ritchie Company	1	..
"	Wheeling	New York and Wheeling Company	1	..
"	Taylor Co	Marion Company	1	..
Kentucky,	Maysville, Mason Co	Union Company	1	..
"	" "	Ashland	1	..
	Carried forward		69	

State.	Town or county.	No. factories.
	Brought forward	69
Kentucky	Cloverport, Breckenridge Co.	1
"	Covington and Newport, opposite Cincinnati	2
"	Owsley Co.	1
Missouri	St. Louis	1
	Total	74

Supposing these works to average 400 gallons of light oil daily, the total production would be 32,400 gallons, or for 300 days in the year, 9,720,000 gallons. The figures of capacity of production represent the amount of light oils only; besides these about half as much more heavy oils and paraffine are obtained, which are more or less converted to useful purposes. The quantities named are approximate averages of the production, which it is impossible to give with accuracy, as the factories are constantly varying in their capacity by the introduction of more retorts and stills. They are presented rather to show the rapid progress made in this branch of manufacture than to attempt to give its real extent. A correct list of all the works cannot yet be made out.

HISTORY AND METHOD OF THE MANUFACTURE.

The possibility of extracting oil from bituminous minerals appears to have been known since the year 1694, a patent having been granted in January of that year to Martin Eele, Thomas Hancock, and William Portlock, for "a way to extract and make great quantities of pitch, tarr, and oyle out of a sort of stone, of which there is a sufficient found within our dominions of England and Wales." This stone proved to be a bituminous shale; and in 1716 it was again applied to similar use under another patent, granted to M. & T. Belton, of Shrewsbury. In the course of the eighteenth century the oily product obtained was employed to some extent as a medicine, under the name of British or petroleum oil. Though from time to time other patents were granted in England for the same process, the business never became of importance there until the successful trials were made by Mr. James Young, of Glasgow, upon the Boghead cannel already referred to. On the continent the subject was brought before the public by the researches of Baron Von Reichenbach in 1829, '30, and '31, when he discovered and separated numerous new compounds from the products of the slow distillation of bituminous substances. The compound he named eupion is the same thing as the rectified oil now known as coal oil, paraffine oil, kerosene, photogenic, pyrogenic oil, and by other local or commercial names. He appreciated its useful properties, and recommended the prosecution of further trials with the object of establishing the best mode of separating it. In France its character was understood in 1824, when a patent was granted for its manufacture; and in 1833 factories were in operation for producing it. In 1834 the method adopted by Selligue was first published, and in the specification of the patent granted to him, March 19, 1845, is a full account of the process as conducted in the works at Autun. This is still the best treatise published upon the manufacture, and notwithstanding the numerous patents which have since been issued, the improvements are limited to comparatively unimportant modifications of the apparatus. In the United States the first patent granted in this manufacture was in March, 1852, to James Young for his process, which in this country was first introduced at the kerosene oil works on Newtown Creek. The next year two patents were granted, in 1854 and 1855 one each, in 1856 six, in 1858 seven, and in 1859 twenty-two.

As mentioned in the preceding chapter, the products obtained by the distillation of bituminous substances vary according to the amount of heat employed and the manner of its application, whether sudden or gradual. Coals thrown into red hot retorts are resolved into large quantities of gas, with the production of inconsiderable quantities of oily compounds heavier in the aggregate than water, and called coal tar. They consist of a variety of hydrocarbons, as the fluids designated by the name of naphtha, the white crystalline substance called naphthaline, the very volatile fluid benzole, besides carbolic acid and a great number of other curious and interesting compounds of hydrogen and carbon. In general they contain a less proportional amount of hydrogen than the products obtained by slow distillation, the fluids are denser, and their boiling points higher.

When the bituminous substances are gradually and moderately heated in retorts, the production of gas is small, the carbon and hydrogen separating chiefly in the form of oily compounds of a greenish color, the specific gravity of which is less than water. These compounds form what is called crude coal oil, and are similar in appearance and composition to the natural petroleum, or rock oil, obtained in some places from the earth, as will be described in the next chapter. Benzole and naphthaline, products of the other method of distillation, are found, if at all, as a result of the employment of too high heat, and instead of the latter the waxy or spermaceti-like substance called paraffine is generated and is held in solution in the oils, from which it may be separated by repeated distillations, and draining off through filters and pressing out the fluid portions of the concentrated residues, at the lowest available temperatures. The oily products are divisible into a great number of distinct compounds by means of repeated distillations, each one being carefully conducted at a certain degree of temperature, and the product which comes over at this degree being kept by itself. But in the large way they are separated into only three classes, which are distinguished as the light oils for lamps, the heavy oils which are suitable for lubricating purposes, and paraffine. Sometimes a mixture of the heaviest oils and paraffine is made use of and sold for wagon grease and such purposes; and the first products which come over in the distillation are kept by themselves, and sold under the name of naphtha (or incorrectly as benzole) to be used as a solvent for the resins, caoutchouc, etc., and for removing grease spots from fabrics.

The proportions obtained from a ton of coal or shale are very variable. The Boghead cannel yields, in well-conducted operations, about 117 gallons of crude oil, from which the product of refined oil is about 60 gallons. It can be made to produce even 130 gallons of crude oil, containing a larger proportion of refined oil than the 117 gallons ordinarily obtained. The Breckenridge coal yields from 90 to 100 gallons of crude oil, and this 50 to 60 of refined oil. The Cannelton coal of Virginia is of similar quality to the Breckenridge cannel. The coals of Ohio run from 55 to 87 gallons of crude oils to the ton, and those of Darlington, Penn., from 45 to 55 gallons. Besides the oils there also come over from the retorts, as in the gas manufacture, a quantity of water rendered alkaline by the ammonia it holds. This collects at the bottom of the reservoirs into which the products are received, and the oil that floats upon the surface being removed the ammoniacal liquors are allowed to escape.

While the general plan of the operations is the same in all the factories, the apparatus is variously modified. By Mr. Young's process the coal is distilled in cast-iron ⏀-shaped retorts, like those employed in making gas, and the volatile products are passed by a worm through a refrigerator kept at a temperature of about 55° F. The oils as they condense drop from the end of the worm into a receiver. Many patents have been granted in Europe and in this country for different kinds of retorts. Some are made of cylindrical form and set upright in the furnace; the charge is introduced at the top and drawn out, when exhausted, at the bottom; the volatile products making their exit either through pipes at the top or at different heights. Some have been constructed of fire clay instead of cast iron. In order that the charge may be uniformly heated, revolving cylindrical retorts have been contrived and patented, first in France many years ago, and recently in the United States. They are sometimes eight feet long and six feet diameter, suspended upon an axle at each end. They are charged through a manhole in the front end like the common horizontal retorts, and the vapors pass out through the axle at the opposite end, which is made hollow for this purpose. Retorts of the size named are charged with about a ton of cannel coal, and four such charges may be worked off in twenty-four hours. They revolve slowly, about twice in a minute, thus turning the charge over and causing it to be uniformly exposed to the fire beneath. At the Lucesco works, thirty miles above Pittsburg, on the Alleghany, ten large revolving retorts are stated to be in operation, each one of the capacity of two and a half tons. They are recommended for the rapidity with which the process is conducted, and the large amount of oil obtained to the ton of coal, while they continue in good order; and on the other hand it is objected to them that the coal is apt to be ground to powder, and the dust is carried along with the vapors, obstructing the condensing worm and adding to the cost of purification. They are, more-

over, expensive to construct and liable to get out of order.

By all these arrangements the fire which causes the expulsion of the volatile matters is outside of the retorts. But the same object is also attained by the use of ovens and pits similar to those used for producing charcoal and coke, in which the material operated upon is itself partially consumed, to generate the heat required to drive off so much of its volatile constituents as may escape combustion. Kilns thus designed for extracting coal oils have been in use in this country and in Europe; and in Virginia, near Wheeling, the plan has been adopted of distilling the coal or shale in large pits dug in the ground of capacity sufficient to contain 100 tons of the raw material. These are covered with earth, and the fire being started at one end, the heat spreads the volatile products forward, and they are drawn out at the opposite end by the exhausting action caused by a jet of steam, and received into suitable condensing apparatus. Some of the kilns are constructed to be fired at the bottom, and the vapors then pass upward through the charge, and are conveyed in pipes from the top to the condensers. The kilns of the Kerosene Oil Company, patented by Mr. Luther Atwood, are made open at the top, and a downward draught through the charge, which is fired on the upper surface, is produced by a steam jet thrown into the eduction pipe that passes out from the bottom of the kiln. A partial vacuum is thus produced, causing a current of air to flow in from the kiln. At the works of this company there are 18 of these kilns in shape like a circular lime kiln, built of ordinary brick and lined with fire brick. They are 20 feet high and 12 feet diameter inside, each one having a capacity of over 25 tons of coal. When this amount of Boghead cannel is introduced it is covered with about four tons of Cumberland coal and a quantity of pine wood. This is set on fire, and at the same time the steam jet is let on. The heated gases from the combustibles above pass through the bituminous materials below; but little air reaches these that is not already deprived of its power of sustaining further combustion. The volatile products are gradually expelled before the slowly increasing heat, and the operation is not completed till the expiration of four days. It is hastened or checked, as may be necessary, by means of the steam jet by which the draught is controlled. What is left in the kiln is unconsumed coal and ashes —no good coke is produced. The condensers at these works are tall cylinders of boiler-plate iron. Passing through a succession of these the vapors collect and trickle down their sides, and the mixed oily and aqueous products are received into iron vats placed in the ground. The uncondensable gases escape into the open air from the top of the last of the cylinders. From the vats the oil rising to the surface flows over into a conduit that leads to a large cistern in the ground of the capacity of 40,000 gallons. The water at the same time is discharged by a pipe, one end of which is at the bottom of the vat, and the other is bent over its upper edge, the flow being caused by the difference of an inch in the elevation of the surface of the two vats. Some oil is carried over into the second vat, and this is separated by a repetition of the same arrangement, and so on through several vats, till the ammoniacal waters are finally allowed to escape after being first received into a large cistern, where some oil still collects upon the surface, and is removed by occasional skimming.

Still another method of conducting the dry distillation is by the introduction of highly heated steam into the retorts, as patented by Mr. William Brown, in 1853, in England and in this country, though this seems also to have been used in the original operations of Selligue in France. The effect of the steam is to aid in heating the charge, while at the same time the vapors are taken up and carried along by it, and protected from being burned or decomposed by remaining in contact with the hot surfaces of the retort. In the subsequent distillation of the crude oil, high steam is similarly applied in the stills.

Nearly the same process of refining is practised at all the factories. The crude oil is pumped up into large stills of cast or boiler-plate iron, with cast-iron bottoms two inches thick. The capacity of these at the works above referred to is 1500 gallons each, and the time required for distilling off this amount of oil is 24 hours. They are heated by fires of anthracite and coke, the latter being itself a product of the distillation and obtained from the inside of the stills after each heat. It is deposited from the crude oil and forms a solid and extremely hard incrustation which is sometimes nearly a foot

thick upon the bottom of the stills. It is a much superior coke to that obtained from the gas retorts, and in its structure is coarsely honey-combed in the upper or last formed portions, gradually growing closer and more compact toward the bottom upon which it adheres. The distillation should be conducted at a temperature not exceeding 800° F., and the process may be rendered continuous by admitting a small stream of oil into the stills. The vapors passing through the goose-neck are condensed in a long worm kept in the water condenser, which should be, in the latter part of the distillation, at a temperature of 80° or more. It is necessary to guard against so low temperature as might cause the paraffine to solidify in the worm, which by stopping the flow of the products might result in blowing up the still. The heat is carefully regulated so that the oil comes over uniformly, flowing from the end of the worm in a steady stream. It is still of a greenish color, with more or less of its peculiar, disagreeable odor. Yet it is evidently purified to a considerable extent by its separation from the free carbon and other impurities, usually amounting to 10 or 12 per cent., which are left behind in the stills. The oils are next pumped into large cylindrical cisterns called agitators, to undergo the chemical treatment, which is in general the same as that practised by Selligue. An addition is made to them of a quantity of sulphuric acid, it may be to the amount of 5 per cent. The mixture is then violently agitated or made to sweep rapidly round by stirrers in the cisterns, moved by machinery. The pure oil and paraffine are unaffected by the chemical agents, but the carbonaceous particles and coloring matters are more or less charred and oxidized, and their condition is so changed that when the mixture is left for some hours to repose, they subside in great part together with the acid, and these can then be drawn off leaving the partially purified oil in the upper portion of the cisterns. This is next washed with about one fifth its quantity of water, which removes the soluble impurities and a portion of the remaining acid. These, after subsiding, being drawn off, a strong lye of potash or soda is introduced into the oil, which neutralizes and fixes what acid remains, and causes the precipitation of further portions of the coloring and tarry matters. The mixture is again agitated and is then left six hours to repose, after which the sediment being drawn off, it is again washed with water, and this too, with the matters it has taken up, are drawn off. In some places chalk or lime has been employed instead of the alkaline lye to neutralize and fix the acid, and the chemical treatment, as it is called, is in other respects variously modified. Though this has been designated the "cold" treatment, the temperature should not be allowed to fall below 90° during these processes.

At last the oils freed from most of their impurities are introduced into stills like those of the first set. The product which first comes over is a very light oil somewhat discolored, which is soon followed by a clear oil having little odor. This gradually increases in density from 0.733 to 0.820, up to which point the mixture of oils is classed as illuminating, and is without further preparation sufficiently pure to be at once barrelled for the market. After this the increasing depth of the color and the greater density of the product indicate that the light oils have been nearly exhausted, and the remaining portions are hence kept by themselves to afford the heavy lubricating oils, and also it may be, by means of fractional distillation, the additional quantities of light oils they still contain, and finally the paraffine which is chiefly concentrated with the last portions. This substance when separated from the oils by filtration and pressure at low temperatures, is of a dark color and somewhat offensive odor; and to bleach and deodorize it have proved to be somewhat troublesome and expensive operations. Exposure to the sunlight has a bleaching effect; but the processes for this purpose have not yet been made public. When obtained perfectly pure and white, difficulties have been encountered in running it into candles, which are not common to other materials used for this purpose. When cooled in ordinary moulds the paraffine would crack in lines radiating from the wick, and the exterior would present a clouded, mottled surface. The method of obviating this difficulty, as described in the French work, "Le Technologiste," of 1859, is to use a mould in two parts, that part for the point of the candle working in the other like a piston. These moulds being brought to the temperature of melted paraffine are filled and then immediately plunged into water at nearly the freezing point. Having remained 3 or 4 minutes, they are taken out and exposed to

a current of cool air for 15 or 20 minutes. The candles then come out, as the movable part of the mould is pushed in, free from defects. This method is successfully introduced into the United States. Paraffine candles have been made at some of the coal oil works, as at those of New York, New Bedford, and Portland. They are of beautiful appearance, resembling the best sperm candles, and at the same time are more economical for the amount of light they afford. The oil that is pressed out from the paraffine is useful chiefly as a lubricator, and from the low temperature at which it is obtained, if for no other reason, it is insured against chilling in cold weather. The residue in the stills, is a mixture of the tarry matters with the portion of the chemical ingredients that was introduced with the oils. For this no use is found. The heavy oils find their principal application in lubricating machinery, and large quantities are consumed for this purpose upon the Western railroads. The heavier natural oils of Ohio, when washed clean from the sand that comes up with them, are also very well adapted for this use; but it is found advantageous to mix either the crude or manufactured article with an equal quantity of lard oil. The petroleum corrects the tendency of this to gum and chill, while it receives additional body from the lard oil. Another use for the heavy oils is for cleansing wool in the woollen factories, and where they have been tried for this purpose, they have been preferred to other oils. In currying leather, also, they are said to have proved a good substitute for fish oil. Experiments have been made with them in Ohio, for mixing paints, and the crude heavier kinds, as those of Mecca, treated in the same manner as linseed oil, boiling them with dryers, etc., formed a good body, covered the wood well, dried rapidly and perfectly, and formed a smooth, hard surface, retaining no odor. The great abundance of the supply of petroleum at the West has led to some speculation as to the probability of the hydrocarbon oils being used for fuel for steamboats, locomotives, and wherever a highly concentrated, portable, and manageable fuel is required. For domestic uses, also, such as require a fire only a little while at a time, the petroleum might be conveniently used in suitable stoves in the same manner that gas is applied to the same purpose. But experiments are wanting to establish the rate per gallon at which it might enter into competition with other fuels upon a larger scale. Besides the heavy and light oils, no other valuable products result from the distillation of the coal oils. Benzole is not a product of this process. It belongs, together with a special class of hydrocarbons designated as the benzole series, to the tar of the gas works; and if ever obtained in the coal oil distillation, it must be by bad management and the use of excess of heat. Some of the light oils, which first come over in the distillation, are often sold as benzole, and are used for removing grease spots—a purpose they answer nearly as well as benzole itself.

The light oils are superior in many respects to any other portable materials employed for illumination. The light they give is exceedingly brilliant, and at the same time pleasant to the eye. They have not the disagreeable odor of sperm oil, nor when spilled upon articles of dress or furniture are the spots difficult to remove. At present prices, the cost of the light is less than half that produced by sperm oil. Coal oils are free from the danger of explosion, which all the so-called "burning fluids" are liable to; and on the score of prudence and humanity their use ought to be encouraged in the place of these dangerous preparations, the employment of which, in spite of the numerous and ingenious safety lamps and expedients to guard against explosion, is continually resulting in terrible accidents and loss of life. The only objection to the coal oils, and the only cause that checks their more general use in the place of all other portable means of producing light, is that the lamps in which they are burned are somewhat more expensive than other lamps, and are incumbered with a glass chimney, which is found necessary for producing a flame free from smoke. Possibly some lamps may yet be contrived in which thorough combustion and a clear flame may be obtained without this inconvenient appendage. In the use of the coal oils a very mistaken preference is given by consumers to the most highly rectified—such as are clear like water; and these are now selling freely at 75 cents a gallon, while the oils of a slightly yellow color hardly find a sale at 60 cents. As regards illuminating power, the latter are actually to be preferred to the former at the same cost, so that the preference given to the clear oils is merely for their appearance.

CHAPTER XII.

PETROLEUM, OR ROCK OIL.

The occurrence of an oily fluid oozing in some regions from the surface of the earth, coming out with the springs of water, and forming a layer upon its surface, has been noticed from ancient times, and the oil has been collected by excavating pits and canals, and also by sinking deep wells. Bakoo, a town on the west side of the Caspian Sea in Georgia, has long been celebrated for its springs of a very pure variety of petroleum or naphtha, and the annual value of this product, according to M. Abich, is about 3,000,000 francs, and might easily be made as large again. Over a tract about 25 miles long and half a mile wide, the strata, which are chiefly argillaceous sandstones of loose texture, belonging to the medial tertiary formation, are saturated with the oil, and hold it like a sponge. To collect it large open wells are sunk to the depth of 16 to 20 feet, and in these the oil gathers and is occasionally taken out. That obtained near the centre of the tract is clear, slightly yellow, like Sauterne wine, and as pure as distilled oil. Toward the margins of the tract the oil is more colored, first a yellowish green, then reddish brown. In the environs of Bakoo are hills of volcanic rocks through which bituminous springs flow out. Jets of carburetted hydrogen are common in the district, and salt, which is almost always found with petroleum springs, abounds in the neighborhood.

Another famous locality of natural oils is in Burmah, on the banks of the Irrawaddy, near Prome. Fifty years ago it was reported there were about 520 wells in this region, and the oil from them was used for the supply of the whole empire and many parts of India. The town of Rainanghong is the centre of the oil district, and its inhabitants are chiefly employed in manufacturing earthen jars for the oil, immense numbers of which are stacked in pyramids outside the town, like shot in an arsenal. The formation containing the oil consists of sandy clays resting on sandstones and slates. The lowest bed reached by the open wells, which are sometimes 60 feet deep, is a pale blue argillaceous slate. Under this is said to be coal (tertiary?) The oil drips from the slates into the wells, and is collected as at Bakoo. The annual product is variously stated at 412,000 hogsheads, and at 8,000,000 pounds.

The Burmese petroleum has recently been imported into Great Britain, and is employed at the great candle manufactory of Messrs. Price & Co., at Belmont and Sherwood. It is described as a semi-fluid naphtha, about the consistence of goose grease, of a greenish brown color, and a peculiar, but not disagreeable odor. It is used by the natives, in the condition in which they obtain it, as a lamp-fuel, as a preservative of timber against insects, and as a medicine. It is imported in hermetically closed metallic tanks, to prevent the loss of any of its constituents by evaporation. At the works it is distilled first with steam under ordinary pressure, and then by steam at successively increasing temperatures, with the following results:—

Temperature. Fahr.	Proportional product.	Character of product.
Below 212°	11	Mixture of fluid hydrocarbons free from paraffine.
230° to 293°	10	" " " containing a little paraffine.
293° to 320°	..	Distillate very small in quantity.
320° to 612°	20	Containing paraffine, but still fluid at 32°.
About 612°	31	Product which solidifies on cooling, and may be submitted to pressure.
Above 612°	21	Fluids with much paraffine.
	3	Pitchy matters.
	4	Residue of coke, and a little earthy matter in the still.

Nearly all the paraffine may be separated from the distillates by exposing these to freezing mixtures; and the total product of this solid hydrocarbon is estimated at 10 or 11 per cent.

Many other localities might be named which furnish the natural oils upon a less extensive scale, as in Italy, France, and Switzerland. In Cuba impure varieties of bitumen are met with flowing up through fissures in the rocks and spreading over the surface in a tarry incrustation, which sometimes solidifies on cooling. In the island of Trinidad, three fourths of a mile back from the coast, is a lake called the Tar Lake, a mile and a half in circumference, apparently filled with impure petroleum and asphaltum. The latter, more or less charged in its numerous

cavities with liquid bitumen, forms a solid crust around the margin of the lake, and in the centre the materials appear to be in a liquid boiling condition. The varieties contain more or less oil, and methods have been devised of extracting this; but the chief useful application of the material seems to be for coating the timbers of ships to protect them from decay. By the patented process of Messrs. Atwood of New York, the crude tar of this locality having been twice subjected to distillation, and treated with sulphuric acid and afterward with an alkali, as in the method of purifying the coal oils, is then further purified by the use of permanganite of soda or of potash. Being again distilled it yields an oil of specific gravity 0.900, which is fluid at 32° F., and boils at 600° F.

In the United States the existence of petroleum has long been known, and the article has been collected and sold for medicinal purposes; chiefly for an external application, though sometimes administered internally. It was formerly procured by the Seneca Indians in western New York and Pennsylvania, and was hence known as Seneca or Genesee oil. At various places it was recognized along a belt of country passing from this portion of New York across the north-west part of Pennsylvania into Ohio. In the last-named state it was obtained in such quantity in the year 1819, by means of wells sunk for salt water, that it is a little remarkable the value of the material was not then appreciated, and the means perceived of obtaining it to any amount. The following description of the operations connected with the salt borings then in progress on the Little Muskingum, in the south-western part of the state, written in 1819, was first published in the *American Journal of Science* in 1826: "They have sunk two wells which are now more than 400 feet in depth; one of them affords a very strong and pure water, but not in great quantity. The other discharges such vast quantities of petroleum, or as it is vulgarly called, 'Seneka oil,' and besides is subject to such tremendous explosions of gas, as to force out all the water and afford nothing but gas for several days, that they make but little or no salt. Nevertheless, the petroleum affords considerable profit, and is beginning to be in demand for lamps in workshops and manufactories. It affords a clear bright light, when burnt in this way, and will be a valuable article for lighting the street lamps in the future cities of Ohio." Several coal-beds were penetrated in sinking these wells.

In north-western Pennsylvania the existence of oil in the soil along the valleys of some of the streams was known to the early settlers. One stream, in consequence of its appearance in the banks, was called Oil Creek. In other localities also it was noticed, and similar occurrences of oil were observed at some places in western Virginia and eastern Kentucky. At Tarentum above Pittsburg, oil was obtained by boring about the year 1845. Two springs were opened in boring for salt, and they have continued to yield small quantities of oil, sometimes a barrel a day. This has been used only for medicinal purposes. On Oil Creek two localities were especially noted, one close to the northern line of Venango county, half a mile below the village of Titusville, and one 14 miles further down the stream, a mile above its entrance into the Alleghany river. All the way below the upper locality through the narrow valley of the creek are ancient pits covering acres of ground, once dug and used for collecting oil after the method now practised in Asia. Cleared from the mud and rubbish with which they are mostly filled, some of them are found to be supported at the sides with logs notched at the ends as if done by whites, and it has been supposed by some that this is the work of the French who occupied that region the first half of the last century. Others think the Indians dug the pits, and in proof of this they cite the account given by Day, in his "History of Pennsylvania," of the use of the oil by the Seneca Indians as an unguent and in their religious worship. They mixed with it their paint with which they anointed themselves for war; and on occasions of their most important assemblages, as was graphically described by the commandant of Fort Duquesne in a letter to General Montcalm, they set fire to the scum of oil which had collected on the surface of the water, and at sight of the flames gave forth triumphant shouts which made the hills re-echo again. In this ceremony the commandant thought he saw revived the ancient fire worship, such as was once practised in Bakoo, the sacred city of the Guebres or Fire Worshippers.

The old maps of this portion of Pennsylvania indicate several places in Venango and Crawford counties where oil springs had been noted by the early settlers. They made some

use of the oil, collecting it by spreading a woollen cloth upon the pools of water below the springs, and when the cloth was saturated with the oil wringing it out into vessels. The two springs referred to on Oil Creek furnished small quantities of oil as it was required, and from a third, twelve miles below Titusville in the middle of the creek, the owner has procured 20 barrels or more of oil in a year.* In 1854 Messrs. Eveleth and Bissell of New York purchased the upper spring, and leased mineral rights over a portion of the valley. They then obtained from Prof. B. Silliman, jr., of New Haven a report upon the qualities of the oil, and in 1855 organized a company in New York called the "Pennsylvania Rock Oil Company," to engage in its exploration. The same year a new company under the same name, formed in New Haven and organized under the laws of Connecticut, succeeded to the rights of the old company; but for two years they made no progress in developing the resources of the property they had acquired. In December, 1857, they concluded an agreement with Messrs. Bowditch and Drake of New Haven to undertake the search for oil. To the enterprise of Col. E. L. Drake, who removed to Titusville and prosecuted the business in the face of serious obstacles, the region is indebted for the important results which followed. After a well had been sunk and curbed near the spring, ten feet square and sixteen feet deep, boring was commenced in the spring of 1859, and on the 26th of August, at the depth of seventy-one feet, the drill suddenly sank four inches, and when taken out the oil rose within five inches of the surface. At first a small pump threw up about 400 gallons daily. By introducing a larger one the flow was increased to 1000 gallons in the same time. Though the pumping was continued by steam power for months no diminution was experienced in the flow. The success of this enterprise produced great excitement, and the lands upon the creek were soon leased to parties, who undertook to bore for oil for a certain share of the product, sometimes advancing besides a moderate sum to the owner.

The country was overrun by explorers for favorable sites for new wells, and borings were undertaken along the valley of the Alleghany river, and up the French Creek above Franklin. The summer of 1860 witnessed unwonted activity and enterprise in this hitherto quiet portion of the state, where the population had before known no other pursuits than farming and lumbering. Every farm along the deep, narrow valleys, suddenly acquired an extraordinary value, and in the vicinity of the most successful wells villages sprung up as in California during the gold excitement, and new branches of manufacture were all at once introduced for supplying to the oil men the barrels required for the oil and the tools employed in boring the wells. From Titusville to the mouth of Oil Creek, about 15 miles, the derricks of the well borers were everywhere seen. On the Alleghany river the number below Tidioute in Warren county, south into Venango county, showed that this portion of the district was especially productive, and the same might be said of the vicinity of the town of Franklin, both up the Alleghany river and French Creek. The wells had amounted to several hundred, or according to one published statement, to full 2000 in number before the close of the year, and from an estimate published in the *Venango Spectator*, (Franklin) 74 of these on the 21st of November were producing the following daily yield :—

	No. of wells.	Prod. bbls.
On Oil Creek,	33	485
" Upper Alleghany river,	20	442
Franklin,	15	139
Two Mile Run,	3	64
French Creek,	3	35
Total,	74	1165

The capacity of the barrel is 40 gallons, and at the low estimate of only 20 cents the gallon the total value of the daily product is not far from $10,000. The depth of the wells is in a few instances less than 100 feet. The shallowest one reported, belonging to the Tidioute Island Oil Company, was 67 feet deep, and its product was 30 barrels a day. In general the depth is from 180 to 280 feet; one well in Franklin is 502 feet in depth, and one on Oil Creek 425 feet. The deepest wells are not the most productive, and the fact of their being extended beyond the ordinary depths may generally be considered an evidence of their failure to produce much oil. There are exceptions, however, to this, one of the deepest wells, that of Hoover and Stewart, three miles below Franklin, producing largely of excellent oil.

* See a pamphlet by Thomas A. Gale, published in Erie, Penn., 1860, entitled "Rock Oil in Pennsylvania and elsewhere."

The selection of localities for boring is very much a matter of chance. Proximity to productive wells is the first desideratum; but this, when attainable, is not always attended with success. The oil does not appear to be spread out, as the rocks lie in horizontal sheets, or if so there are many places where it does not find its way between the strata, and wells near together from which oil is pumped do not always draw upon each other. No doubt the system of crevices and pervious strata through which the oil flows in its subterranean currents, is very irregular and interrupted. The valleys to which the operations are limited are narrow, and are bounded on each side by hills, the summits of which, from 250 to 400 feet above the bottoms, are on the general level of the country. The increased expense that would be incurred in sinking from the upper surface and in afterward raising the oil to this height, as also the uncertainty of finding oil elsewhere than in the valleys, have so far prevented the explorations being extended beyond the creek and river bottoms; but it cannot be long before the capacity of the broad districts between the streams to produce oil is thoroughly tested. At present the most favorable sites are supposed to be near a break in the hills that form the margin of the valley, as where a branch comes into the main stream. An experiment is already undertaken to test the high grounds west of Tidioute branch.

As the bituminous coals are known as a source of hydrocarbon oils, it is natural to suppose that the springs of oil found near the coal region are fed from the coal-beds or bituminous shales of the coal formation. But it happens that only a few oil springs of western Pennsylvania have been struck in the coal-measures themselves, and that some of these are sunk into the underlying groups of rock to reach the supplies of oil. The oil districts are in general outside of the coal-field and upon the outcrop of lower formations which pass beneath the coal-measures, the whole having a general conformity of dip. Hence the slope of the strata is toward the coal, and an obstacle is thus presented to the flow of the oil from the coal-field toward its margin; and though under some circumstances the elastic pressure of the carburetted hydrogen gas might force the oil considerable distances from its source, it is hardly to be supposed that this should first find its way down into lower formations and then be carried many miles (30 to 50) and find its outlet in another district, rather than to the surface at some nearer point. The strata of north-western Pennsylvania lie nearly horizontally, their general inclination being toward the south. The highest rock upon the summits of the hills of the oil region is the conglomerate or pebbly rock (the floor of the coal-measures). Beneath this are series of thin bedded sandstones, slates, and shales, alternating with each other with frequent repetitions. The shales, often of an olive green color, are readily recognized as belonging to the Chemung and Portage groups of the New York geologists—a formation which overspreads this portion of the country, extending in New York two thirds of the way toward Lake Ontario and as far east as Binghamton. It is also continued through Ohio, crossing the Ohio river at Portsmouth, and in this state is known as the Waverley series. Under this is a heavy bed of bituminous shale, 200 or 300 feet thick, called in Ohio the black slate and in New York the Hamilton shales. This group contains an immense amount of carbonaceous matter, and oil is often disseminated through it. Sometimes it runs out in springs and finds an outlet by the occasional fissures in the beds. Dr. J. S. Newberry, who has given much attention to this subject, is of opinion that this formation contains sufficient carbonaceous material to be the source of the oil, and that the more porous and open shales and sandstones of higher formations are its reservoirs. Such is the geological formation of the Seneca oil region and of the oil springs of Canada West, which are the districts affording this product most remote from the coal-field. But from whatever source the oil may be derived, its origin is at the best very obscure, and little light can be thrown upon the probability of the supply long enduring the heavy drain made upon it by hundreds of wells worked by powerful steam pumps. But though actual experience alone must determine the extent of the quantities of oil stored up and the period they will last, there is certainly encouragement to be drawn from the never-failing yield of the oil districts of Asia, which for centuries have poured forth without stint their rivers of oil.

The sinking of wells is conducted after the usual method of boring artesian wells. After much uncertain consideration of the chances, a particular spot is selected, more,

perhaps, from the hope of its being the right one than from any very practical grounds for the choice; but as the oil flows only in crevices among the strata, the location is frequently determined—other things being equal—by the prospect of reaching the rock at a few feet from the surface, and thereby avoiding the necessity of sinking an open well or driving pipes through unknown obstacles down to the rock. If the bed rock is found within ten or fifteen feet, the boring is begun at once. The derrick being raised, an elm, hickory, hemlock, or other elastic timber is cut down, some 25 or 30 feet in length. The larger end is fixed in a notch of a tree, or heavy post planted in the ground, and another post is set under it at a distance from the but determined by the elasticity of the timber. The spring of the pole should be sufficient to raise the drill quickly, with its iron connecting rods, weighing often 300 pounds. The rods are suspended from the free end of the pole by a swivel or simple bolt-head, turning freely around. At the commencement of the boring, the rods being very short do not weigh more, including the drill, than 70 or 80 pounds. Two men, therefore, jerk them forcibly down, to increase the momentum of the drill; the spring of the pole immediately raises the drill for the next stroke, while at each blow a man gives it a slight turn so that it may cut a round hole. Several other methods are employed for making the pole spring; by one, which is conveniently worked without employing steam or horse power, a sort of double stirrup is suspended from the pole into which two men place each a foot, and pressing the stirrup suddenly down it immediately springs up again with the drill. This is much used, though some wells are sunk by horse-power machinery, and some by steam engines of four or five horse power.

As the well is constantly deepening, while the stroke of the spring-pole (about 30 inches) remains constant, a vertical adjusting screw about 18 inches in length is attached to the end of the spring-pole; the rope is clamped to the lower end or nut of this screw, and then extended to the pulley above. As the well deepens, a slight turn of the screw lowers the rope with the rods attached to it, and thus keeps the drill always free to fall to the bottom with an equal stroke. The work is continued, by a constant succession of strokes, to a depth of about fifty feet, successive lengths of iron rods being screwed on as the hole deepens—increasing the weight of the tools to about 300 pounds. The use of any additional rods is then dispensed with, and the upper rod is suspended by a rope attached to the spring-pole, and continued above the pole around a pulley and windlass, used to raise the boring tools when it is necessary to draw them out. They are drawn up in this manner at intervals of an hour or two, in order to sharpen and temper the drill, and to make room for the sand pump. This is a thin iron tube, a little more than half the diameter of the hole, with a simple valve at the bottom opening upward. It is lowered by a cord to the bottom of the well, then raised up with a jerk, and suffered to drop again by its own weight. This is repeated quickly eight or ten times; a whirl is thus produced in the water below which stirs up the mud and small pieces of broken stone; as the tube drops, the mud and small stones enter the open valve and are retained when the tube is drawn out.

The jarrers are employed to increase the force of the spring-pole when the drill happens to be wedged in the hole by broken pieces of stone or by other obstructions. They are two rectangular links about 18 inches in length, formed of stout bars of iron, and connecting the upper rods with the lower. When the drill descends to the bottom, the upper link, as it descends, slips down eight or ten inches in the lower link, and when the pole springs up the upper link has the advantage of moving through this space, and thereby giving a sudden upward jerk to the drill rod. The force of this upward jerk is greatly increased by a heavy rod introduced above the upper link, and which, as it moves up, lends its momentum to the stroke.

The hole is carried down by three men at different rates according to the nature of the strata encountered, varying from a foot or less to six feet in a day. In the hard sandstones of quartz pebbles firmly united together, two or three inches sinking in 12 hours may be all the progress practicable. The material brought up is carefully scanned for any oily appearance indicating the proximity of oil, and the well is watched to observe if any carburetted hydrogen gas escapes from it, which is considered a favorable sign.

The process of drilling in the rock is considered by all concerned in boring for petroleum, a very simple and even welcome operation, especially when contrasted with the

uncertainties and apprehensions that surround the driving of pipes. At the outset, the cost of four iron pipes and bands long enough to reach a depth of forty feet, is equal to that of a complete set of boring tools with the rods and ropes sufficient to bore half a dozen wells of 300 feet each in depth. There is often great uncertainty of knowing how deep the pipes will have to be driven, and it is impossible to foresee the various obstacles through which they have to go. When the work has gone down successfully 70 or even 100 feet, the lowest pipe is often suddenly broken or takes an oblique direction. The pipes in the ground are then abandoned, and a new set driven in another place, although in several instances pipes reaching 60 feet in depth have been pulled up by a lever and axle, with chains or rods attached to a lewis wedge driven into the bottom pipe.

The pipes are of cast iron, generally ten or twelve feet long, about five inches bore, and the shell full an inch thick. The lower end of the first pipe is not sharpened, but is driven down blunt as it comes from the mould. The pipes are fastened together in the simplest manner possible, by wrought-iron bands, the ends being turned off, leaving a neck somewhat larger than the interior diameter of the bands, to receive them when expanded by heat.

Through common earth or gravel the pipes are forced down by the ordinary process of pile-driving; but when large stones are encountered, or round boulders as large as a man's head, there is great risk of breaking or turning the pipes. As soon, therefore, as the pipes meet with any great resistance the driving is suspended and the drill is applied to break up the stone or to bore a circular hole in it, which is afterward reamed out as large as the interior diameter of the pipes. The driving is then resumed, and in soft shales the pipes are often forced on, crushing down the sides of the hole, and making their way through to the depth of 12 or 15 inches in the rocky stratum.

The cost of boring a well 200 feet deep is generally estimated at from $1000 to $1500. The latter sum includes the cost of all the tools and materials, and also of a small steam engine, a large tank of pine plank, in which the product is collected for the oil and water to separate, and it also allows for such accidents and delays as are common to these operations.

When the oil is struck it often rises up in the well, sometimes flowing over the top, and in several instances it has burst forth in a jet and played like a fountain, throwing the oil mixed with water high up into the air. Such jets have rarely lasted long, and are usually interrupted by discharges of gas, the elasticity of which drives out with violence the fluids mixed with it, as champagne wine is projected from a bottle on removing the cork. Hundreds of barrels of oil have, however, been wasted at some of the wells for want of means to collect it or stop its flow in its sudden first appearance. At Williams' well, half a mile below Titusville, about 100 barrels of oil were collected the first night the oil was reached, and a large quantity besides was lost. A similar event occurred near Tidioute, the oil rushing up so violently as to knock over the laborer who held the drill and to pass through the derrick and over the trees around. After a time the spouting wells become quiet and the oil settles down, so that it has to be raised by pumping. The pumps are contrived to work at any depth, and by men, or by horse power, or the steam engine. For a time at some of the wells the product has been water alone or water mixed with a little oil; and after pumping several days this has given place to oil with a moderate proportion of water. If the pumping be suspended for a day water accumulates, and it may be several days before this is drawn out and the former yield of oil recovered. The water is generally salt. The flow of oil has rarely if ever been known to fail entirely except by reason of some obstruction in the wells, and in such cases it has usually returned after the hole has been bored out larger or made deeper. The supply is not, however, altogether regular in any of the wells, even after the flow has settled down to a moderate production of 10 or 15 barrels a day. The maximum yield of a well for a considerable time is about 50 barrels a day, and from this the production ranges down to 4 barrels, below which it is considered insufficient to pay expenses.

The oil and water are conducted from the pumps into the large receiving vats, and after the water has subsided the oil is barrelled for the market. From the upper Oil Creek it is mostly wagoned to the Union Mills station in Erie county, on the Erie and Sunbury railroad; and from Tidioute to Irvine, at the mouth of the Broken Straw, on the same road. But most of the oil along

the Alleghany river and French Creek is taken by steamboats down the river to Pittsburg. New York city is at present the principal market, but the country refineries are already taking a considerable share of the oil.

The product of the different wells varies somewhat in quality and value. At Franklin the oil for the most part is heavy, marking as low as 33° Baumé, which corresponds to specific gravity 0.864. Some of the wells furnish oils of 35° or 36°—on Oil Creek the range is from 38° to 46°, at Tidioute 43°. The French Creek oils are heavy. It is not unlikely that the depth of the wells may have some effect upon the quality of the oil, as from very shallow wells those of the lighter varieties must be likely to escape by evaporation, leaving the heavier portions behind. The oils obtained at Mecca, Trumbull county, Ohio, are heavy oils, being thick like goose grease and marking 26° or 27°, which is equivalent to specific gravity 0.900. At Grafton, Lorain county, Ohio, the oil is even darker and thicker than this, marking about 25° B.

With the exception of some light, clear oils of reddish color, the petroleum is usually of a greenish hue, more or less deep and opaque. It has an offensive smell which is not entirely removed by the ordinary methods of deodorizing practised in the refineries. The process of purification is similar to that of the coal oil manufacture, as already described. The proportion of light oils separated by distillation varies with the crude petroleum employed. The largest product is about 90 per cent., and from this less amounts are obtained down to about 50 per cent. The properties and uses of these products have already been considered in treating of coal oil.

To complete this account of the petroleum of the United States more particular mention should be made of the extension of the district from north-western Pennsylvania into New York on one side, and Ohio on the other. In Chautauqua, Cattaraugus, and Allegany counties, N. Y., are many places where the appearace of small quantities of oil upon the surface, and the escape of jets of carburetted hydrogen, indicate the existence of petroleum below; and the names of Olean and another Oil creek, a branch of the Genesee river, suggest the probability of this proving another oil district. About a mile north-west from Cuba in Allegany county, is a pool about 20 feet across and 10 feet deep that has always been called an oil spring, its surface being covered with a coating of oil from which supplies have been obtained for medicinal purposes. A pipe was sunk into this, and on the 3d of January, 1861, when it had been driven down 20 or 30 feet, oil mixed with water suddenly gushed up with great force. Oil also appeared on the water drawn up from an artesian well sunk to the depth of 130 feet in the same vicinity. Arrangements are now in progress for thoroughly testing the capacity of this district.

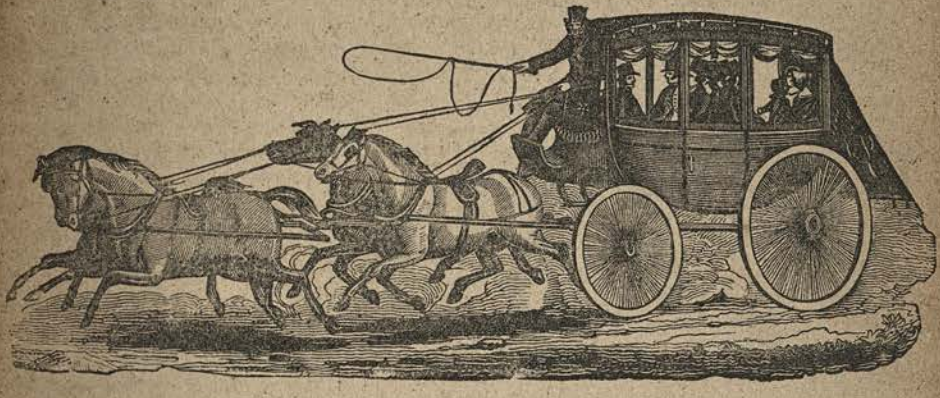
In Ohio the oil-producing counties are Noble, Adams, Franklin, Medina, Lorain, Cuyahoga, Trumbull, Mahoning, and some others. Near Cleveland and in the valley of the Cuyahoga oil appears in many places, but it has not yet proved of much importance. The vicinity of Mecca, Trumbull county, is the most productive locality. Operations were commenced there in February, 1860, and in November it was stated that between 600 and 700 wells had been sunk, and 75 steam engines were in operation pumping oil. Two of the wells were yielding from 50 to 100 barrels a day each. This statement is probably much exaggerated, and while others report that several hundred wells have been sunk, a dozen or more are said to be working profitably. These wells pass through the same formation as those near Titusville, but for the most part they are shallow, ranging in depth from 30 to 100 feet, and the most of them not much exceeding 50 feet. About 30 miles south-east from Mecca, at Lowellville, Mahoning county, a well was sunk 157 feet which proved very successful, yielding 20 barrels of oil a day. This well was commenced in the conglomerate and ended in the Chemung strata. Duck Creek, Noble county, was formerly noted for the oil which appeared with the brine of the salt wells.

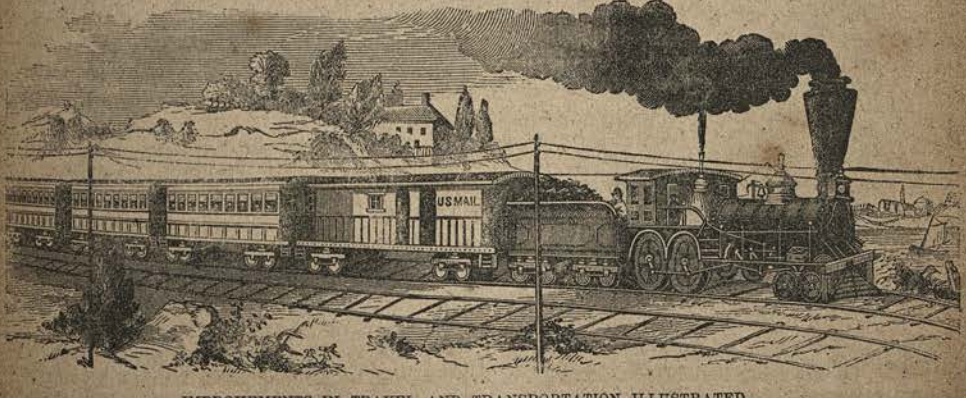
In Ritchie and Wirt counties, Virginia, near the Ohio river, some wells are producing oil, and this promises to be an important oil district. Canada West also contains an oil region, extending from London toward the St. Clair river, from which petroleum has been obtained the last two years. The value of the product, however, is considerably deteriorated by its insufferable odor. On the southern coast of California petroleum is said to be found in considerable quantities; and springs of it are described by Captain Stansbury in the report of his expedition to the Great Salt Lake, in 1849, as occurring

about 83 miles east from Salt Lake City, in the vicinity of sulphur springs and beds of bituminous coal.

The works for refining petroleum (excepting some originally designed for manufacturing coal oil) were all constructed in 1860–61. Their localities and approximate capacity, as far as known, are given below:—

Localities.	No. factories.	Daily capacity. Bbls.	Remarks.
Pittsburg, Penn.	2	..	Built for coal oil.
Tidioute, Warren Co., Penn.	1	35	
Union, Erie Co., "	1	35	Destroyed by fire.
Meadville, Crawford Co., "	1	50	
Franklin, Venango Co., "	1	10	
Titusville, Crawford Co., "	2	30 & 40	Not completed.
Oil City, mouth of Oil Creek	1	..	" "
Buffalo, N. Y.	1	..	
Cleveland, Ohio	1	..	Built for coal oil, recently burnt.
Columbus, "	1	..	
Canfield, "	1	..	Built for coal oil.





IMPROVEMENTS IN TRAVEL AND TRANSPORTATION ILLUSTRATED.

TRAVEL AND TRANSPORTATION.

CHAPTER I.

EARLY ROADS—POST ROADS—MACADAM—NATIONAL.

Of all the marvels that have marked the present century, those which manifest themselves in the development of the means of locomotion and transportation are among the most wonderful. With the emancipation of the states from their colonial condition, and the formation of a federal government, a most extraordinary activity seems to have been imparted to the inventive faculties of the Anglo-Saxon race, and to which side soever we direct our attention, we find that all the great and useful creations of genius take date from that auspicious event. The art of transportation has, as it were, been created. Not that our fathers were not possessed of the means of transportation by land or water, but those means were so immeasurably below those now in use, that it may be fairly claimed that a new art has been created. When our fathers landed on these shores, it is easily understood that they found no roads, or carriages, or other means of moving from one place to another. Indeed, the countries they had left were at that time but poorly provided with such means, as compared with what they have at present.

The first attempts to exchange the products of labor, which mark the nascent commerce of a people emerging from barbarism, are developed through manual labor, and the application of the strength of animals in a rude and imperfect way. The peddler with his pack, and progressively his pack-horse, are the instruments of intercourse in an infant society. From village to village, pathways are formed, wheel-carriages are invented to gather the fruits of harvests, and they wear their own paths upon the surface of the soil, and finally the road is constructed, more or less perfect, as a means of transport between places more or less distant. In such a state of affairs the roads are very imperfect, and the carriages of the rudest description. It is conceivable that the first step from the pack-horse and its pathway, to the two-wheeled cart and a road was a very great advance—nearly as much as from the road to the railway. And this improvement has by no means been of so distant a date as at first we might imagine. Not only is the construction of good roads of very recent date, but up to the present moment a very large portion of the world called civilized is without them. Certain parts of Europe, the French colony of Algiers, and the United States alone possess them. In other words, but little more than one-quarter of the inhabited part of the globe is provided with roads. In China a large part of the internal land transportation is upon human backs. With the exception of one or two important communities, the extensive empire of Russia, with 60,000,000 inhabitants, is without roads; communication is kept up only in the winter, when the ground is frozen, by sledges. Spain is little better off than Russia, and Italy has few of such improvements.

The condition of affairs in this country before the construction of roads is evident to the hardy pioneers of the western frontier, and has been at times common to every part of the country. The first settlers on arriving here, it is certain, found no roads, and were not skilled in following an Indian trail. They built their houses upon the summits of hills, as well to avoid the miasmata of swamps as to get notice of the approach of hostile savages. The connection between these houses was by foot-paths that became horse tracks, and with the progress of events were enlarged into wagon roads. These, ultimately fenced in, became the highways, running irregularly over the face of the country, as they were prolonged by settlements. The science of road making never guided their direction, nor would farmers

permit the squareness of their fields to give place to the straightness of roads. These highways are made in the general idea of making the passage of a vehicle between any two given points possible, and various expedients are resorted to, to overcome obstacles at the smallest expense. The plough turns up the sides, and the scraper draws the earth to the summit, which is levelled off to be hardened by travel. The reduction of hills or the filling in of swamps is not resorted to in new settlements, but the latter are mostly made passable by laying down logs across the track, and parallel with each other. This (*corduroy*) road is better than a swamp, but offers so great resistance that a far less load can be drawn over it than over a smooth, level road. The roads of the whole country, encountering these natural difficulties, took their character from their location, and transportation in each district was more or less difficult, according to circumstances. The best roads of the day were such as would now nowhere be tolerated; as a general thing, the water-courses, so abundant in the country, were the main arteries, and most roads were directed toward these, or in the neighborhood of a large city they converged upon it as a common centre.

The number of even these roads at the date of the formation of the government was not large, nor was their quality to be admired. The streams and water-courses were well supplied with small craft, that delivered goods and produce between distant points, but where the route left the water, the transportation became difficult and expensive. The war and its success had deeply stirred the public mind, and imparted full activity to the independent genius and enterprise of the people. Those 3,000,000 of souls occupied, as it were, but a foothold on this immense continent, to the ultimate possession of the whole of which they already looked forward. The means of transportation were the first object and desire that presented themselves to thinking men. Steam, as a power of locomotion, was unknown, and the science of road making little developed. Canals, therefore, presented themselves almost simultaneously to leading men in various sections. General Washington had, before he attained his twenty-first year, crossed the mountains and given his careful attention as an engineer to the subject of canals, more particularly the connection of the Chesapeake with the Ohio river. At a subsequent period he received the thanks of the Virginia House for his report on the results of his examination of the valley of the Ohio. And the war had no sooner closed than we find him, in 1784, presiding at a commission sitting at Annapolis, on behalf of Maryland and Virginia, to consider the improvement of the navigation of the Potomac, which improvement ultimately, in after years, became a canal to Pittsburg. General Washington, as an engineer, always took an active interest in works of internal improvement. When the Dismal Swamp canal, connecting the Chesapeake, at Norfolk, Va., with Edenton, Albemarle Sound, North Carolina, a distance of 28 miles, through the vast Dismal Swamp, was projected and executed at the expense of individuals with some government aid, he took some of the stock. One certificate of this stock, originally issued to him for £300, or $1,000, was sold in 1825, at auction, in Alexandria, for $12,100, to Judge Washington. Pennsylvania, nearly at the same time, appointed commissioners to explore routes for connecting the Delaware with the lakes. They reported in favor of the Juniata, partly by canal and partly by river. The result was a charter of the Schuylkill and Susquehanna Company, in 1789, and the Delaware and Schuylkill in the following year, with $400,000 capital. In New York the active mind of Gouverneur Morris had already projected the Erie canal. In Massachusetts, the Middlesex canal, 30 miles, was authorized in 1789, and navigated in 1804. In South Carolina the Santee canal was finished in 1802. These, with many other events, show the activity of the public mind at the date of the birth of the Union, in relation to means of transportation. It will be remembered, however, that the people were then few in number. They were heavily in debt. Their productions were small and trade limited. There was no surplus capital to carry out those magnificent ideas, which were in advance of the times. The natural water-courses of the country ran through the finest farms and delivered most of the produce upon noble bays, which were well provided with ships to transport it abroad for sale. This natural traffic absorbed all the commercial capital of the country, but it was so profitable that in the course of a few years it supplied accumulations for other objects, and it was left for a few years later to witness the prosecution of great en-

terprises. The roads of the country were in a terrible state, however, and since the new constitution had empowered Congress to establish post-offices and post-roads for the conveyance of the mails, it became its duty to look to the roads, and this was the first practical bond of union between the states. A systematic connection of every town in the whole thirteen states, by state routes under one organization, completed the means of communication and established passenger routes. The statistics of the post-office afford a very good indication of the progress of that kind of transportation :—

MAIL SERVICE.

	No. of post offices.	Miles post roads.	By stages. Miles.	Sulkies and horses. Miles.	Steam. Miles.	Rail. Miles.	Annual. Miles.
1791.....	89	1,905	89,650	756,818	..	..	846,468
1811.....	2,403	37,031	2,534,102	3,058,960	..	..	5,592,652
1833.....	8,450	115,176	17,693,839	8,531,909	628,737	..	26,854,485
1859.....	27,977	260,052	23,448,398	27,021,658	4,569,962	27,268,384	86,308,402

This table gives the transportation of the mail in the first year of its operation; in 1811, when steamboats began to run; in 1833, when railroads began to claim a share; and in the past year, when all these means have been more fully developed in all sections of the country. There are thus three distinct periods of transportation: 1790 to 1810 were 20 years of common roads and sail vessels; from 1810 to 1830 were 20 years of canals and steamboat progress; and since 1830 there have been 30 years of railroad progress, which has produced immense results, throwing an entire net-work over the surface of the country between the Atlantic and the Mississippi, and superseding other means of transportation. It is to be observed that in the first year of the operations of the post-office department, there were but 1,905 miles of post-roads, and that on these, nine-tenths of the service was on horseback, the stage service being very small; but as the roads were improved up to 1811, the stage service came nearly to equal the horse service. From that date steam began to take the mails that ran on or near water-courses, and subsequently to 1830 the railroads began to compete with the stages on land; since that time the stage service has increased but six millions, while in the previous 20 years it had increased over fifteen millions of miles. The extension of post routes has been in 70 years, it appears, over 258,000 miles in the whole country, and the federal government has taken an active part in the extension of roads. The most important work of this kind undertaken was the Cumberland or national route across Ohio, Indiana, and Illinois to St. Louis. For this purpose, large annual appropriations were made by Congress. Other roads in many directions were projected, particularly from Washington to New Orleans; and in the frontier states, numerous roads were constructed by the troops under the direction of the war department.

It was thus that the federal government imitated imperial Rome, which in the days of its power clearly understood that that power was to be maintained only by the rapid march of its legions. From the "eternal city," noble causeways ran to the remotest corners of the then world. These were military routes simply, and intelligence was conveyed upon them from station to station with great rapidity. On the fall of the empire, those noble works, instead of being preserved for the uses of commerce, were in a great measure demolished by small states, as a means of preventing invasion. Nevertheless, those Roman roads remained the best roads in England down to the present century. What is called Ermine street connected London with Carlisle, in Cumberland. Another is known as Watling street. Apart from those old works, the roads of England were no better than those of this country up to the present century. In this respect there is great difference between the works of the Romans and those of the United States. Those old Roman roads had no competitors. During 1,400 years they continued the best means of conveyance. The United States roads, on the other hand, were hardly done before the inventive spirit of the age set up a successful rival in the giant railway, which has become *the* trunk road. The French government, under the empire, saw the necessity of roads, and began a system for Europe. The noble way over the Simplon was the first of these. With the fall of the empire that system became confined to France, but has since been vigorously pushed—$20,000,000 per annum was expended for many years in their construction.

There were in 1815, 3,000 leagues of "royal" roads, and these had increased to 10,000 in 1850. 2,000 leagues of departmental, or county roads had, in the same time, increased to 12,100, and town roads were extended by 15,000 leagues. These extended means of communication have imparted to French prosperity much of its strength.

In the United States the impulse given to road building by the federal government was taken up by the several states, if not directly at the public expense, yet by laws which compel inhabitants to work on the local roads. These regulations are different in different states. The essential features of all the laws are nearly the same as in the state of New York, where the directing power is in "commissioners of highways," who are chosen in each town. Under these overseers are also chosen. The commissioners direct as to the grade of the road, general shape, drainage, etc. The overseers summon the persons who are to work, see that they do actually work, collect fines and commutation money. Every person owning land, and every male over twenty-one years, is assessed to work. The whole number of days' work shall be at least three times the number of inhabitants in each town. Under this system the roads are never very good. The commissioners work gratuitously, and skill, labor, and time are never to be had for that price. The overseers, being changed every year, are never experienced in the undertaking. The men they summon go to it as a half holiday, and the work the overseer sets them at is pretty sure to be that which most benefits his own place. The money subscribed is not expended in the best manner. These are all circumstances which do not favor the construction of such roads as will greatly reduce the cost of transportation. In the laying out of the road in this way, a passable track is the most aimed at.

To admit vehicles, the track must be cleared of wood by the ax-men, swamps must be overlaid with materials, rivers bridged, and the route laid around hills in order to avoid the difficulties of ascent. These are the main points to make a road practicable. It is very soon discovered that transportation on a bad road is much more expensive than on a good, and efforts are accordingly made by the most enterprising to improve the bad roads. The first step is to make the roads in such a manner as to accommodate the greatest number of people, and at the same time allow the largest loads to be drawn by horses. The better the road the larger will be the load that a team, or two horses, can draw at a given speed, and of course, the cheaper the transportation. It is to be understood, however, that the road must be equally good for the whole distance that a load is to be drawn, since if there is a space where great difficulties are to be encountered, the load must be gauged to meet that difficulty, no matter how good may be the remainder of the road. If a highroad leading through one township is not kept up, it neutralizes the public spirit of those adjoining; hence the necessity of a general system to insure continuous cheap transportation. To effect this, science has devoted its attention, but with little effect in the manner that country roads are made and kept in repair. The requisites of a road are: 1st, straightness, because straight lines are the shortest; 2d, it should be as level as possible, because every ascent causes a loss of power. Thus, if a horse draws on an ordinary level road two tons, and comes to an ascent of one foot in every twenty, he cannot ascend, because, in addition to the draught, he must lift up 200 pounds, or one-twentieth of the whole weight through the whole height. To make the road level, and save this labor and expense, the road must wind round the hill. There is little lost by this, because generally it is no further round than over. To prove this, cut an egg in half longitudinally, and set it upon the table; the line which goes round the base is the same as that which goes over the top. The half of an apple or any other body will give the same result. Even if it were longer, it is better to go round, since the horse can do the last and not the other. The road should never be less than a rod wide, to allow two vehicles to pass. The surface of the road must be as smooth and hard as possible, in order to overcome as much as possible the resistance offered by sinking in, which is very serious, because the depression creates little hills before the wheels. Thus, if a wheel four feet in diameter sinks in one inch, to overcome the resistance thus offered one-seventh of the load would require to be lifted up over it. The harder the road, the less the resistance from this source. The greater the number of stones, hard substances, and inequalities there are to be encountered, the greater the resistance from collision. The resistance of *friction* is propor-

tional to the roughness of the road, and the extremes of this may be illustrated by a carriage wheel on gravel and a rail wheel. The loss of power on a road, or in other words, the cost of transportation, is increased in proportion to the increase of these resistances, and inversely as they are diminished. To overcome them many improvements have been gradually adopted, such as earth, gravel, broken stone, stone pavements, wood, and railroads.

In marshy forests charcoal roads are made. Timber from 6 to 18 inches thick is cut, 24 feet long, and piled up lengthwise in the centre of the road in such a manner that the pile will be about 12 feet high. This is covered with earth, taken from ditches on either side. When the wood is charred, the coal is raked down to the width of 10 feet, with a depth of two feet in the centre and one at the side. Such a road becomes very compact, and free from dust. Such a one in Michigan cost $660 per mile.

In the older states mostly plank roads were at one time favorites, and many hundreds of miles were constructed at a cost of $1,250 per mile. This plan has been generally abandoned. The roads not kept up are a nuisance, and many have been complained of, and removed as such.

Gravel roads have sometimes been made with the gravel from the shores of rivers, but the resistance offered by these roads is considerable.

The modes of road making here alluded to, are those which are prevalent mostly in the country districts, and where the work is performed as a tax. These answer for cross roads; but the great thoroughfares were taken in hand either by the state or by authorized companies.

Turnpike companies were chartered by most of the states, with the intention that they should construct roads having all the requisites of the best routes, and they were authorized to make a charge to those who use them. These, like most corporations, were subject to abuse; and the people were compelled to pay tolls when they had gained nothing in the way of easier transportation. New England, New York, Pennsylvania, and other states, authorized a number of companies which answered a purpose before railroads. The New York turnpike laws enact that vehicles having tires six inches wide shall pay half tolls, those with nine inches, one quarter, and those 12 inches, none at all. These enactments were designed to encourage the use of broad tires, as being less destructive to roads, but where the road is well made, as on the Macadam plan, the breadth of the tire has no effect; on the other hand, the horses' feet do the most damage. It has been calculated that a set of tires will, in average weather, on a macadamized road, run 2,700 miles, but that a set of shoes will bear only 200 miles travel.

The Macadam road, invented by a Scotch gentleman of that name, was introduced in 1820. The principle is simply that stones broken into angular fragments not over a certain size, say that of a pigeon's egg, will, under the pressure of wheels, combine into a compact mass, excluding all water, and, therefore, not subject to the action of frost, and be as solid as the original stone. These have proved to be the best roads, answering most of the conditions, and, therefore, allowing of transportation at the smallest cost. Good, well-made pavements, as used in cities, are better, since they give little resistance, and afford a foothold to the horses. In order to understand the difference in value of these roads, it may be remarked that a machine has been invented called a dynamometer. It resembles a spring balance; one end is connected with the carriage, and the other with the horses, and the power they exert is shown by the index. By such an instrument it was determined that, on a gravel and earth road, the resistance to draught of one ton was 147 lbs.; on a Macadam road, 65 lbs.; on a good pavement, 33 lbs.; and on a rail track, 8 lbs. Whence it appears that a horse can draw three times as much on a Macadam road as on an earth road; on a pavement, four and a half times as much; on a railway, eighteen times as much.

These figures indicate the gradual advance made in the power of transportation, since the roads, under the action of the state and federal government, and of the enterprising towns and cities, gradually improved from mere wagon ways to well-constructed roads in those sections where land carriage was most used. While individuals, companies, and states thus contributed to the improvement of roads, the federal government entered the field with greater vigor.

There were two motives for the construction of roads and internal improvements by the federal government. The first was to facilitate the mails; and the second was to

facilitate communication. It was obvious that the new and infant states had little means to expend in the construction of roads that were to be more or less for the general benefit. The government, therefore, in organizing new states upon the national territory, made provision for the construction of roads out of the proceeds of the public lands sold within each state. The government everywhere constructed numerous roads, and after the war of 1812, when its finances began to be easy, it employed the French General Bernard and a corps of engineers in the construction of fortifications and roads. Among these engineers was Capt. Poussin. This gentleman went back to France, carrying with him the republican ideas here collected. He there propagated them with such effect that he was, in 1848, when the Revolution chased the last Bourbon from the throne, attached to the Paris *National*, the republican newspaper, and became, in consequence, ambassador of the provisional government to the United States in 1849. Thus, after the lapse of a quarter of a century, returning to the scene of his early labors.

When the state of Ohio was admitted into the Union, there were very few roads there, and the federal government was the chief proprietor of the land. It was agreed, therefore, that two per cent. of the proceeds of the land sold should be applied to the making of a road leading to the state. The same condition was made when Indiana, Illinois, Missouri, Mississippi, and Alabama were admitted, and the road was commenced. A turnpike road from Baltimore, 270 miles to Wheeling was laid out, and a similar road from Washington, 150 miles to Wheeling was constructed. From that point the Cumberland road runs 135 miles to the east bank of the Ohio; of this distance, 85 miles are in Pennsylvania, 35 in Maryland, and 15 in Virginia. This was extended west 80 miles to Zanesville, and so through the states of Ohio, Indiana, and Illinois, to St. Louis. The road has cost the government over $3,500,000. Its effect upon transportation was very great. Before its construction it required, to go from Baltimore to Wheeling, 8 days. This was reduced to 3 days. The figures were the same for the length of travel from Washington to Wheeling. Its influence upon the country through which it ran was great. Villages multiplied in its neighborhood, and the value of property was much enhanced. The city of Wheeling was particularly influenced by it. In the year 1828 it forwarded to Baltimore over that road 3,500,000 lbs. or 1,750 tons of produce, by over 1,000 wagons. Anticipations were then indulged that a small reduction in the cost of transport would bring 100,000 tons of Ohio produce over the road to Baltimore. They did not then foresee that the reduction in cost would be brought about only by rails to Baltimore.

The Cumberland road by no means monopolized the attention of Congress, but roads were constructed in most of the states under the war department, and in the new states the army was employed in making them. Some 800 miles were thus made in Arkansas. We may allude to a few of these roads, as that to Mars Hill, Maine; Detroit to Fort Gratiot, Michigan; do. to Saginaw bay; do. to Chicago; Laplaisance bay to the Chicago road; Fort Howard and Fort Crawford; road to the Chattahooche; canal surveys in Florida; road to Apalachicola; Pensacola bay to Pittsburg; road from Jackson to Fulton, Mississippi; Memphis to Little Rock; Green bay to Winnebago. These few names of roads spreading from Maine to Arkansas and Florida will give an idea of the extended works of the government, which also embraced removing obstructions of rivers and improving river navigation. A grand system of internal improvements was thus developed, until its growing magnitude made it a political issue, and the whole system came to an end under the Maysville road veto of General Jackson. The principle was adopted by one party, that the federal government had no power to construct any but strictly national works, or not any that were entirely within a single state. The system thus came to a violent end, after an expenditure of some $30,000,000, but not until railroads had begun already to supersede canals and roads. The federal government had thus lent a powerful hand to the extension of highways. The great thoroughfares that it had laid open had facilitated migration and settlement, and wherever these had taken place, local roads multiplied, until we find that in the present year there are 260,052 miles of post-road in the Union.

The mails of the government were given out by contract to the highest bidder for four years' service. The whole mail service was divided into sections, north, east, west, and south, each being let for four years; but

every year one of those fell due. The contractors agreed to deliver the mails on certain routes in a given time, for a certain amount of money. The mail money was generally depended upon for the expenses of running the vehicles, and such passengers as could be carried by the same conveyance afforded a profit. Thus the system for the circulation of letters and newspapers became the machinery for the circulation of the people. These accommodations were, however, far from being luxurious at a distance from the great cities. In these, indeed, the staging was conducted in a style approaching the splendid. The eastern stages running into Boston, and penetrating into every part of New England, were celebrated for their quality and style, as were those of New York, Philadelphia, and Baltimore, and most other large cities that were the centres of traffic, as well as post service. The different "lines" ran such opposition, as reduced the fare and promoted speed. The dandy "turn-out" being ready at the hour, well dressed, polite, smart drivers received the "ribbons" with gloved hands, and the "team" went through with a skill that could get the best time out of the nature of the road. As the traveller receded from the great centres, he found the "teams" worse, and the roads to match. The mails ran fewer times in the week, the vehicle dwindled from the easy coach to the covered spring wagon, to the open wagon without springs, ultimately to the horse, and finally perhaps to a man's back, and the traveller's accommodation diminished in proportion

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CHAPTER II.

COASTERS—STEAMBOATS—CANALS.

In the neighborhood of the water-courses the traveller was better accommodated by the coasting vessels. The early settlements of the country had been, as a matter of course, upon the coast and on the numerous streams with which the country is supplied. The roads had extended back, more or less, into the country from these settlements, where the freights accumulated at the landings, whence they were carried by water for interchange with other towns, or, as the country grew, to be exported abroad. The wagon charge for freight was always so high as to absorb the value of the produce at moderate distances, and travelling was mostly upon horses, unless water conveyances could be availed of. This was the common mode for long journeys on all the rivers. The following advertisement, from a New York paper early in the present century, gives an idea of the style of travelling in the youth of men now not old.

"Sloop Experiment—for passengers only.—Elias Bunker informs his friends and the public, that he has commenced running a sloop of about 110 tons burthen, between the cities of Hudson and New York, for the purpose of *carrying passengers only*. The owners of this vessel, being desirous to render the passage as short, convenient, and agreeable as possible, have not only taken care to furnish her with the best Beds, Bedding, Liquors, Provisions, &c., but they have been at very great expense and trouble in procuring materials, and building her on the best construction for sailing, and for the accommodation of *ladies and gentlemen travelling on business* or *for pleasure*.

"Merchants and others residing in the northern, eastern, or western counties, will find a *great convenience* in being able to calculate (at home) the precise time they can sail from Hudson and New York, *without being under the necessity of taking their beds and bedding*, and those in New York may so calculate their business as to be certain of comfortable accommodations up the river."

This was evidently no common luxury that Capt. Bunker proffered to an admiring public. They were no longer required to "take up their beds and walk." Ladies and gentlemen travelling for pleasure could now be supplied with bedding, as well as other luxuries, on board a hundred ton sloop, and depend upon the time of her *leaving*. The wary Elias did not commit himself to the time of her arrival, however. Long experience had made him cautious on that point. However, to be certain of leaving was something, since the taking of a passage had been only a preliminary step to a voyage. The completing of the freight, the waiting for a wind, and the notification by means of a black man to be on board at an appointed hour, were now to be dispensed with. This was a great blessing, a good way in advance of the navigation 150 years previous, when permission was granted to a sloop to go from New Amsterdam (New York) to Fort Orange (Albany), provided she did not carry

more than six passengers. This was the mode of reaching most of the large cities. From any point of the eastern coast the best mode of reaching Boston was by the lumber or other coasters. In these the passengers, male and female, were stowed away in a few berths in the cabin, or *sprawled* around upon the uncarpeted floor. Sometimes these vessels, when the freight earnings were eked out by a fair number of passengers, as from Bangor, Portland, or other cities, were raised to the dignity of a "packet," when a few extra berths were decorated with a red bombazette frill of rather a scanty style. In the rainy seasons, spring and fall, these were almost the only modes of travelling. It may be supposed that passengers were not very abundant. The vessels, however, improved in size and accommodation, and the number of passengers still, even in these railroad days, conveyed by them is, perhaps, as large as ever. The speed of these vessels was not great, and the uncertainty of arrival such as now would by no means suit ideas of business. In those seasons of the year when the roads were generally good, the stages would make four miles per hour and arrive in fair time. Such arrangements did not permit frequent visits for the purchase of goods, and most business was done fall and spring, when the goods followed the water-courses as far as possible, and then paid from 15 to 30 cents per ton per mile, according to the difficulties of the route. Even the mail charge was from 6¼ to 25 cents per single letter, or a letter on one piece of paper, being 18¾ cents for any distance between 150 and 400 miles—envelopes, of course, were not used. Those charges were continued down to 1845, when the reduction took place.

The tonnage employed in the coasting trade had increased from 68,607 in 1789, to 420,362 in 1812. Inasmuch as but little change had taken place in the speed and build of the vessels, the increase indicates the progress of business. In 1807 the enterprising sloop owners who, like Captain Bunker, had conceived the idea of furnished berths for the accommodation of the public, were struck aghast at the success of Fulton's "Clermont"—named after the country seat of Chancellor Livingston—steaming up the river at the rate of four miles an hour under all circumstances. The conservative interests were loud in demonstrating the utter ruin that was to overtake river craft, the occupation of boatmen, and, consequently, the navy, "the country's right arm of defence," by means of this great innovator. Nevertheless, the spark of genius had kindled the flame of invention, and the public were becoming absorbed in it. Each new steamer exceeded the previous ones in build and style, and the machinery underwent as rapid improvement. As usual, however, the public were slow to be convinced. It was admitted, when it could no longer be denied, that steam would answer for the river, but it was held to be idle to attempt the Sound navigation in those new-fangled concerns. This problem was decided in the Fulton by Capt. Bunker, possibly our enterprising friend of the sloop. The "Hell-gate" passage was, in those days, an object of terror. An English frigate had been lost there in the old war, and there were not a few who still held the idea that "the devil only could beat those English who had beat the Dutch." The East River rushing up the Sound at particular times of tide pours a tremendous flood between Ward's and Long Islands. The passage narrows to a few yards, and the tide rushes past the "hog's back" and the "gridiron," turns at right angles, and forms a foaming whirlpool around the "pot-rock," which, even with the surface of the water, is fatal to any vessel that touches it. Through that "gate of Hell" the steamer was to pass, and the operation was described by a passenger as follows:—

"I remember the long-agitated question, whether steamboats could be made capable of sea navigation, or so constructed as to traverse our sounds, bays, and coasts in safety. This question was put to rest by the enterprise and skill of Capt. Bunker. In the Fulton, constructed, I am told, with a view to crossing the Atlantic, he undertook the navigation of Long Island Sound, an arm of the sea in which the most severe tempests are often encountered. During a season of no extraordinary moderation, including the two equinoctial gales, Capt. B. lost but a single trip. Another doubt remained to be removed. It was supposed impossible to pass the celebrated passage of Hell-gate against the tide, at the strength of the current. This was reserved for Capt. Bunker to remove, and I happened to be on board at the time of the novel and interesting experiment, returning southward from New Hampshire. A number of respectable passengers witnessed the performance. It was in the boat Connecticut, built with all the strength to be obtained

and careful workmanship. The machinist (McQueen) was accompanying his engine to prove its powers, with careful and ingenious assistants, and some of the owners were on board also. The first attempt to pass the point of greatest pressure of the contracted stream was unsuccessful, and the boat was compelled to retreat into an eddy and increase her steam. With renovated power the effort was repeated, every man fixed immovable at his post, the passengers properly stationed in different parts of the boat, the engineers employing their utmost diligence to force the passage. They were again defeated by the supposed resistless stream, and again retreated, racked, strained, and shivering, from the contest. After a short pause and fresh preparation, it was resolved by the parties concerned to make a third endeavor, and test the strength of the machinery by the greatest trial it could ever be expected to bear. After a severe struggle, in which a weaker vessel would have been disjointed and torn to pieces, the headstrong current yielded to the giant power of steam, and the triumph of art over nature was effected. A few moments of greater breathless anxiety I scarcely ever witnessed. Mechanical science achieved a victory over elementary force, and overcame an obstacle heretofore deemed in this manner altogether insurmountable. The courage and perseverance of Capt. B. were so conspicuous on this occasion, that I can never forget the impression made on all present. We have since found it as easy to traverse our sea-board, navigate the Mississippi, and cross the Atlantic, as it was to find America after Columbus had broken the egg."

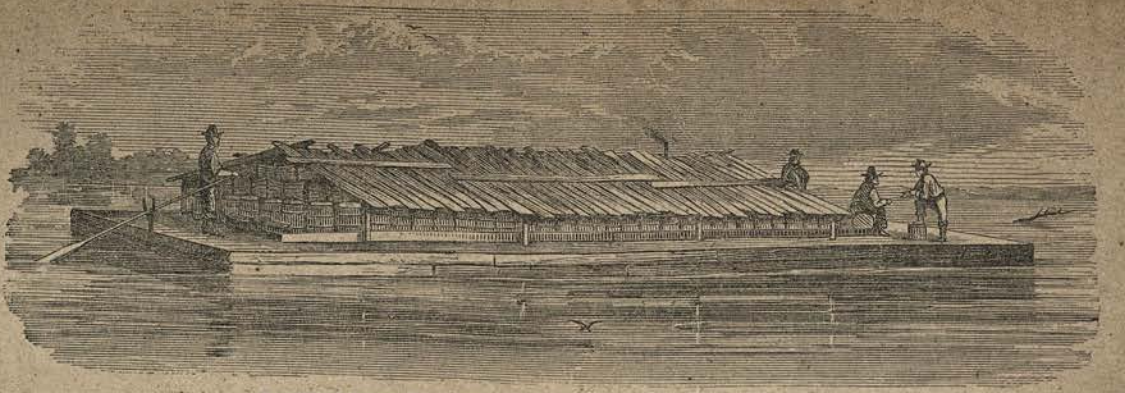
To those who now so frequently make that dire passage without knowing it, this animated description must afford surprise as well as amusement. It is suggestive, not so much of the temerity of the "bold navigators" of that day, as of the feeble nature of the boats then built. The passage, to be sure, has now been deprived of some of its "horrors" by the removal of the pot-rock, which has been broken by gunpowder blasts to a depth which leaves it no longer dangerous. The noble steamers of the present day pass through at all times of tide, without apparently feeling the current, instead of butting at it three times "strained and shivering." The Fulton, after performing this feat, passed up the Connecticut river for the first time to Middletown. The North River boats continued to improve, and the time of the Clermont—36 hours to Albany—was, in 1820, reduced by the Paragon to 20 hours. In 1823, however, the time from New York to Providence, 200 miles, was 20 hours, and the stage to Boston completed the route, 40 miles, in 6 hours more, making 26 hours. At that date steamers were multiplying on all the Atlantic rivers and bays, and on the western rivers, as well as on the lakes. In 1819 the first steamer crossed the Atlantic from Savannah, Georgia, to England. In 1825 the Chief Justice Marshall had reduced the time to Albany to 14 hours 30 minutes. The progress in speed may be seen at a glance in the following figures:—

1811, Clermont's time to Albany, 4 ms. per h.,		36 hs.
1820, Paragon,	" "	27
1825, Chief Justice Marshall,	"	14.30
1840, Knickerbocker,	"	9.33
1860, average time 18 miles per hour,		8

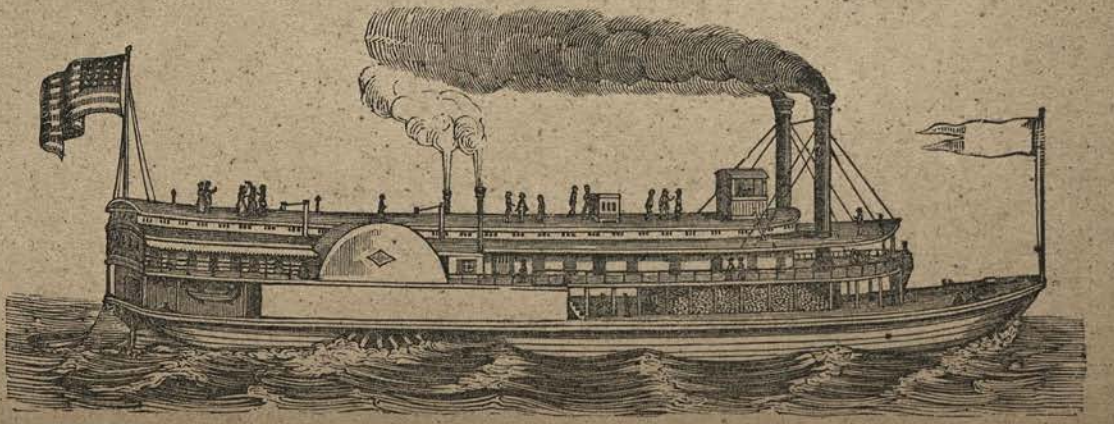
With the opening of the Erie canal in 1825, the quantity of goods going and coming much increased the demand for transportation, and barges in tow of steamers began a new era in that buisness. That goods could be carried west on the canal, and so by continuous water-courses on the lakes and their affluents, induced more passengers by the same route. In 1841 the new principle of propelling by screw was introduced by the patent of Capt. Ericsson. The iron screw steamer R. F. Stockton, of 72 tons, came from Liverpool under the command of Capt. Crane, and became a tug on the Raritan canal. Those steamers now gradually gained ground in public favor. The speed was long not so great as that of the paddle wheels. This has been gradually overcome by improved models and forms of screw, until in the month of October, 1860, two propellers of 100 feet length were launched for the North River trade, and made time 18 miles per hour, being the fastest boats for their length afloat. This class of vessels may ultimately be exclusively used in the European trade.

The settlers who had crossed the mountains in the early times of the government had located mostly on the great streams, within easy reach of the means of conveying the surplus to points of sale. They were not provided with vessels of a very expensive construction; and flat boats were the chief means of descending the streams. These vessels, designed only to go down stream, were composed of such material as, after

having served the purpose of transporting produce, could be broken up at the place of destination, and sold as lumber. These were improved into keel boats, for the purpose of ascending the streams, and in either case were propelled by long poles in the hands of the boatmen. These, standing on the gunwale at the extreme bow of the boat, thrust the pole into the mud, and setting the shoulder against the top, pushed the boat forward with the feet in walking toward the stern, which reached, they drew up the pole, walked back, and repeated the movement. In this laborious mode of travel, all the merchandise sent from the east, *via* New Orleans, reached its destination. It required four months to travel thus from New Orleans to St. Louis—a distance of 1,500 miles, and the cost of the goods, it may well be supposed, was enhanced by the process; while, on the other hand, the produce sent down realized but little. Thus, between the cheapness of the produce and the dearness of merchandise received in exchange, the settler realized but little for his labor. It is easy to conceive how great a blessing was steam on those waters, to enable the weary men to stem the ceaseless, downward flow of the mighty currents. In 1811 that blessing made its appearance at Pittsburg in the shape of a steamboat, built by Fulton, and which had a considerable success. The general progress was, however, slow, for the reason, among others, that, as in all such cases, there was a large capital invested in river craft, which would depreciate in value in face of the new power, and there was not much capital to embark all at once in steam. It was also the case that Chancellor Livingston, the partner of Fulton, claimed a monopoly of the lower Mississippi trade, and put a restraint for some years upon steam in that region. So great a power could not, however, but force its way. With the construction of the Enterprise, in 1815, St. Louis was reached in 25 days from New Orleans, and public enthusiasm was aroused. There were, however, up to 1817, still but twelve boats upon the western waters, of an aggregate tonnage of 2,335 tons. The time to Pittsburg was 54 days, of which 36 days was running time. These passages caused much excitement, and a bold merchant predicted that the rate of freight between New Orleans and St. Louis would fall to $3.50 per 100 lbs., but he was regarded as visionary, or what they would now call in Wall-street language a "bear" in freights. His sanguine nature would probably have been surprised could the veil of time have been so lifted as to permit him to see 35 years ahead—the boats of the present day making money at 40 cts. per 100 lbs., and carrying it in three days, instead of 25. The Monongahela and Ohio Steamboat Company claimed patronage because their new crack boats could go nine miles an hour! But they were in advance of the times; that speed was thought to be dangerous, even if possible. Those people are now, however, not quite satisfied unless the speed is equal to 25 miles in still water. The war had given a new impulse to settlements west; the more so that steam now so much facilitated travel, and freights multiplied in proportion. Thus reciprocally the improved means of travel induced more locomotion, and increased traffic more demand for vessels. The multiplying boats and more rapid passages still found a sufficiency of business, and even the old river craft were kept in requisition for tow boats. Cincinnati began to build barges of 100 tons to go to New Orleans in tow of steamers; and the Etna made the passage down in fifteen days, reflecting great glory on the commercial enterprise of that city, and its citizens became elated. A Cincinnati writer of 1817 estimates the territory drained commercially by that city at 10,000 square miles, and remarks: "Supposing this settled by 40,000 families, and that each farm would give two tons annual surplus for exportation, there would be 80,000 tons to send to New Orleans, or freight for 800 boats of 100 tons each." The writer apologizes for the extravagance of this estimate. Commercial enterprise began to seek new routes. In 1823 three keel boats in tow passed 450 miles up the Wabash river. It was not until 1826 that the first steamer ran up the Alleghany river. In the same year the ship Illinois reached St. Louis from New York, *via* New Orleans, 3,000 miles, in twenty-nine days and a half, and the first steamer ran up the Susquehanna to Tioga. The opening of the Erie canal, in 1825, caused a great change in travel. Thus the journey from New York to Pittsburg was accomplished by canal, with only eight days staging, and thence down the river to New Orleans. In 1824 the passage up from New Orleans to New York, *via* Pittsburg, was made in 24 days, at an expense of $90. The passage from Natchez to Philadelphia, 2,500 miles, was equal to 17 days. In



FLATBOAT FROM ST. LOUIS TO NEW ORLEANS, TIME FOUR MONTHS.



STEAMBOAT FROM NEW ORLEANS TO ST. LOUIS, TIME THREE DAYS.

the same year a remarkable voyage was projected from Charleston to Green Bay. It was a sloop of six tons, with six passengers, and it reached Rochester in 15 days from Charleston. The passage of a gentleman from Detroit to Washington and back in 16 days was regarded as a miracle.

The remarkable progress of steam upon the Mississippi may be estimated most readily by a table of the passages at different periods, as follows:—

NEW ORLEANS TO ST. LOUIS—1,300 MILES.

Prior to steam		120 days.	
1815, Steamer	Enterprise	25 "	
1823, "	average passages	12 "	
1826, "	General Brown	9 "	12 hours.
1828, "	"	9 "	4 "
1860, "	running time	3 "	

The time between New Orleans and St. Louis was thus diminished under the various improvements suggested by experience in the form and mode of running steamers. A boat of 350 tons when fitted out will now cost some $50,000, and will carry 500 tons down stream, or 1,500 bales of cotton on deck. Twenty years ago the freight of cotton down from Memphis was $2 per bale, and below Natchez $1 per bale. The charge for freight up from New Orleans to Natchez was 75 cts. per 100 lbs. As the business increased, larger boats were built. Of these the Eclipse was the type. She carried 1,200 tons, but was too large to pay; and boats are now constructed of a less dimension. The Mississippi boats are large flat-bottomed boats, drawing from 15 to 50 inches of water. The speed depends upon the circumstances of the channel. That of the Memphis, recently built for the St. Louis and Memphis trade, is 18 miles in still water per hour. With light draught and great pressure, a speed equal to 24 miles in still water has been attained. The Altoona ran between Alton and St. Louis, 25 miles, in one hour and forty five minutes, and in one hour down; average down and up, one hour and twenty-five minutes. Eighteen miles is said to be the time of the western boats. Those rivers flow with gentle currents in mostly shallow water; and there have been various changes in the fashion of the boats. The stern-wheel boat, we believe, is peculiar to those rivers. Instead of having two wheels, paddling, one on each side, one wheel, 20 feet in diameter, is placed directly at the stern, athwart ships, and by its revolutions pushes the boat ahead. These boats are not remarkable for their speed, but answer in narrow and shallow streams. The regular steamers have their main decks within four or five feet of the water, and the guards overhanging the bow give them the appearance of a New York ferry-boat. The paddle wheels are generally much further aft than in the eastern steamers. The after part of the main deck is devoted to freight. Above the main deck from 10 to 18 feet is the saloon deck, which extends nearly over the whole of the main deck. The saloon is surrounded with state-rooms, which open into it, as well as on to a promenade which goes entirely round the outside of the boat. The saloon is from 150 to 250 feet long. Above this deck is a promenade deck, over which is a long tier of state-rooms, and this, in its turn, is surmounted by another promenade deck, which has the pilot-house at its front, and which is usually 50 feet from the water. But formerly, when there was no restraint upon reckless steam pressure, or the explosive qualities of the boiler, its *height*, as well as that of the decks, was very uncertain. The "crack boats" are now built from 300 to 400 feet, with 36 to 40 feet beam, eight feet hold, and draught of water, light two feet, and loaded four feet. These steamers are now free from those reckless races which formerly so endangered life, when the safety-valve was fastened down, the furnace stuffed with tar and pitch, and the captain, rifle in hand, ready to shoot down the pilot of the opposing boat at the critical moment when the least deviation in steering would lose him the race. Those barbarous times have passed with the frontier manners of the passengers. Their sporting, drinking, gambling, fighting, have given place to business, temperance, prudence, and refinement, while wealth rolls up in the cities as a result of the speedy and cheapened transportation which the steamers have effected.

The increase of steam tonnage on those waters, has been as follows:—

	1842.	1851.	1860.
New Orleans	28,153	34,736	70,072
St. Louis	14,725	31,834	55,515
Cincinnati	12,025	24,709	23,136
Pittsburg	10,107	16,943	42,474
Louisville	4,618	15,181	29,037
Nashville	3,810	3,578	5,263
Wheeling	2,595	7,191	11,545
Vicksburg	..	938	..
Memphis	..	450	6,143
Galena	..	..	5,849
Total tons	76,033	125,360	249,039

It is a matter of course that when the speed of these vessels has increased in the manner indicated, their efficiency for traffic has progressed in the same ratio. In the 25 days that were formerly required to go from New Orleans to St. Louis, a steamer of the present day will make eight passages, and will carry more freight. Hence, the number of tons does not indicate the growth of the trade. If the number of tons is three times greater, the business is 30 times larger. The effect of the great reduction in the freight on goods may be illustrated by a single example. Thus, in 1815 cotton cloth was 30 cts. per yard, and 25 yards weighed 100 lbs., which would consequently be worth $30. The transportation of this at that time from New Orleans to St. Louis would cost $5, or 17 per cent. of the cost. The same quantity of cloth is now worth $9.00, and the transportation from New Orleans to St. Louis 40 cts., or 4½ per cent. of the cost. These figures speak of the greater money value realized for products, and the increased quantities of merchandise procured for that money value.

The war of 1812, by interrupting trade on the Atlantic, had induced a large migration to the west, when steam was opportunely developed to facilitate trade and traffic at the same time. The return of peace found a large population west of the mountains in the full tide of prosperity, and in the Atlantic states great excitement in regard to steam, with multiplying manufactures, which sought a market in the growing west. Under such circumstances the old canal projects for opening up the communication were revived in full force, the more so that the war had nearly destroyed the usual water communication.

Instead of transporting merchandise in sloops and schooners along the coast, now no longer safe from the enemy, recourse was had to wagons over roads not the best in the world. This was necessarily very slow and costly. The traffic between New York and Philadelphia, for instance, was carried on in a Conestoga wagon, drawn by four horses, and that which covered the distance of 90 miles in three days was known as "the flying machine," and the value of goods at either end of the round showed great fluctuations, enhanced by the expense. This extra expense for the whole coast alone, it was asserted, would have paid the whole cost of a system of internal navigation from Maine to Georgia. It was then that the enterprises to which the great minds of the Revolution had given birth at the peace of 1783 began to be realized, and two objects were sought, viz.: a safe inland water communication along the whole Atlantic border, to operate in case of war, and another was to connect the waters of the west with the east, and the public began to regard with more favor the project of uniting the lakes to the Hudson river. Mr. Morris, who had suggested it at the close of the Revolution, wrote an able report in its favor in 1812, when the war gave new interest to it. The undertaking was formidable, and New York applied to the federal government and other states for aid, but her application was met with jeers and ridicule. The result was the determination of the state to undertake it alone, when the return of peace allowed of more facility for its execution; accordingly, on the 4th of July, 1817, the Erie canal was commenced with great ceremony, Governor De Witt Clinton turning the first earth, and it was completed October, 1825. The event was celebrated with the greatest pomp along the whole line, and in the city of New York. The canal is 363 miles long, 40 feet wide at top, 4 feet deep, and the capacity of boats, 80 tons. The construction cost $7,143,789, or $19,679 per mile. This immense work gave the long-wished-for communication between the great lakes and the tide waters of the Atlantic. In the same year, viz., October, 1817, a canal connecting the waters of Lake Champlain with the Erie canal some miles from Albany was commenced. This Erie and Lake Champlain or Northern canal is 63 miles long, and was completed at the close of 1823, at a cost of $1,257,604, or $19,962 per mile. The Erie canal proved to be the most successful work of the kind in the world, and within 10 years discharged in full the debt created for its construction. The great success of the work not only gave an impulse to canal building in other states, but induced the state of New York to embark in new undertakings of the same nature, which have not proved so successful. These were what are called the lateral canals, draining the country on either side, into the grand canal. The Oswego canal runs 38 miles from Lake Ontario to the Erie canal, at Syracuse. It cost $55,437, and was finished in 1838. The Cayuga and Seneca lake runs 23 miles from those lakes to the Erie canal at Mon-

tezuma, and was finished in 1829, at a cost of $237,000. The Chemung canal, connecting the Chemung river with Seneca lake, 39 miles, was finished in 1838, at a cost of $316,000. The Crooked Lake canal, 8 miles, was finished in 1836, for $120,000. The Chenango connects the Susquehanna at Binghamton with the Erie canal at Utica, 96 miles, and was finished in 1837, at a cost of $2,417,000. These canals never paid their expenses, and became a burden upon the revenues of the Erie. There were also in New York, the Genesee Valley canal, 108 miles; Black River and feeder, 87 miles; the Delaware and Hudson, 83 miles; and the Oneida, 8 miles.

The great success of the Erie, as we have said, roused the emulation of other states, and during the five years succeeding the opening of the Erie the air was filled with canal projects, only to name which would occupy much space. We may mention some of the most extraordinary, however: a canal from Boston to Narragansett bay; Long Island to Canada, *via* the Connecticut river; Boston to the Connecticut river; a canal over Cape Cod; Providence to Worcester; a ship canal across Central America. These projects only indicate the extraordinary activity that the Erie success had imparted to the public mind. Those which were evidently the most needed for present and future commerce, were immediately undertaken. The Chesapeake and Ohio, to connect the waters that the name designates; the Ohio canal, to connect Lake Erie with the Ohio river; the Farmington canal, in Connecticut, afterward used for a railroad site; the Chesapeake and Delaware, to connect those waters, were all ready, and broke ground July 4, 1825, three months before the Erie was finally completed. These works, with many others, which we shall take up in their order, were pushed to completion, under various difficulties, inasmuch as that they required a large amount of money, but they had an immense influence upon traffic, and called into requisition an amount of engineering skill which had never before been demanded in the country, and various success has attended the construction. The object of a canal is, of course, to float boats that contain merchandise, between two points, in order to reduce the expense of the transportation. The canal is therefore constructed with some regard to the amount of business that will be required of it. The channel must be excavated on the level soil, carried over gaps and rivers by embankments that will hold the water, and it must be fed by abundant streams.

The channel is excavated with the two sides sloping at the same angle, which varies with the nature of the soil. The base of the slope is commonly to the height as 5 to 4. The bottom of the canal is generally the breadth of two boats upon the deck, in order that they may pass. The depth of water in the canal should be at least one foot more than the draught of the boats. The tow-path is about two feet above the level of the water, and about ten feet wide. When the canal runs through a sandy soil, or one that does not easily retain water, the bottom is "puddled." This process is to mix clay well with gravel and put it on in successive layers of two or three inches thick. When a new layer is put on, the old one is roughed up to make both adhere well. When repairs are needed, they are generally done at the time the water is let out for the winter. The bed of the canal is so laid as to give a gentle current to the water. The levels are the distances between the locks, and each level, proceeding downward, has a less elevation than the preceding one. In a hilly country these locks are frequent, and in some cases are continued for a distance, like steps up and down a declivity. Thus the Erie canal, on leaving Lake Erie at Lockport, descends 60 feet to the Genesee river. To perform this, ten double locks built in masonry are required, but the canal has also one level of 63 miles without a lock. The lock is a chamber built of timber or masonry, as large as possible for the size of the canal. The boats must not exceed what can be admitted to the locks. The top of the lock is above the surface of the water, and its bottom is level with that of the next lower level. Each end of the chamber is closed by heavy swinging doors, which open in the middle against the direction of the current. The doors being a little broader than the lock, they meet in the middle at an angle, and the weight of the water presses them together. When a boat going up the canal comes to a lock, it passes between the open gates, which close behind it. The water is then let in from the upper gates, until the lock being full, the boat floats to the upper level, generally about 10 feet rise, but sometimes 18 feet. It passes out, and another boat being ready to go

down takes its place, when, the upper gates being closed, the water is let off below and the boat lowers with it to the lower level. A lock full of water is thus discharged. It follows that a large supply of water must be had to replace what thus passes off, in addition to leakage and evaporation. The engineer of the Erie canal calculated the loss by leakage was 100 cubic feet per minute. For supply, reservoirs are often constructed. Canal branches, called feeders, are made to bring water from distant sources. Steam power is also used to raise water to the required level. This is the case with the Illinois and Michigan canal; the waters of Lake Michigan being pumped up to the summit level. In some cases inclined planes are substituted for locks. In these cases the boats run upon trucks, which are then, by the power of steam, dragged up the plane to the higher level. In the Morris canal, of New Jersey, these have a slope of one in 21. These are the general features of all the canals, but the influence they have upon transportation depends, of course, in some degree, upon the localities and the capacities of the work. Boats are commonly towed upon a canal by horses. A single horse can draw upon a good road a ton at a speed of 2½ or 3 miles per hour, and can draw as easily 70 tons upon a canal at the same speed. The difference in cost is immense. Instead of 24 cents a ton for one mile land carriage, the Erie canal charges 6 mills per ton per mile, or one-fortieth part of the expense. The freights charged are distinct from the state tolls. It is obvious that where the boats are of greater capacity, allowing of a larger quantity to be passed down at the same passage, the cost of transportation is much diminished. Thus the Delaware and Hudson canal had a capacity for 50 ton boats, and coal was carried 108 miles for $1. The enlargement of the canal so as to admit boats of 100 tons reduced the cost 65 cents, but some of the boats carry 148 tons at proportionate rates. When the routes of the canals of other states threatened to affect the business of the New York canal, the reduction of the cost by means of enlargement was the means resorted to to retain the trade, and the enlargement has been prosecuted at great expense. The principle of the enlargement was based upon the fact that as the canal is abundantly supplied with water, the only limit to its capacity would be the time required to pass boats at the locks. It was calculated that 26,000 boats can be locked each way in a season. The old canal boats were about 70 tons, hence the utmost capacity of the canal would be 3,640,000 tons; but by the enlargement the boats were to be of 224 tons burden, hence the tonnage would be 11,648,000 tons, if the quantity moving each way was the same, but the down freight is as four to one of the up, which reduces the capacity to 7,230,000 tons. Before the canal was built, the expense of transportation from Buffalo to New York was $100 per ton! and the time 20 days. A ton of wheat in New York was then worth about $33, hence the transportation was three times the value of the wheat, six times the value of corn, and twelve times the value of oats. As a consequence, the wheat of western New York at that time went down the Susquehanna to Baltimore as the cheapest and best market, as the lumber of the head waters of that river now goes. When the canal was opened, the freight down was about $14 per ton, more or less, according to the character of the freight. This has gradually been reduced, and in 1850, when the railroads for the first time were allowed to carry freight, it was $3 to $7 from Buffalo to New York. By the enlargement it is supposed the rates will be reduced to $1.82 between Albany and Buffalo. Since the permission of railroads to carry freight, however, the business of canals is more confined to those heavy freights furnished by the raw produce of the country, lumber particularly. Those coarse and bulky articles that are of low money value as compared with their weight will continue to move upon canals, but the lighter and more costly, as well as those pressed for time, will be carried exclusively by rails. These latter have some disadvantages, however, as in the case of flour, the motion of the railroad causing it to waste, an objection not urged against canal travel.

The total length of the five great lakes is 1,555 miles, and the area 90,000 square miles, and they are estimated to drain an area of 335,515 square miles. That vast tract of waters was a waste as far as transportation went until the year 1797, when the first American schooner was launched. The craft increased to some extent for the small commerce that engaged the settlers when there was no outlet either to the Atlantic

or to the south. In 1816, however, a steamer was built on Lake Ontario, and in 1819 the Walk-in-the-Water, 340 tons, was launched at Buffalo. The most of the trade, however, consisted in the operations of the Indian traders, carrying westward supplies and trinkets for the trade, and returning with furs and peltries. On the opening of the Erie canal, in 1825, a new state of things presented itself. Western New York threw off its frontier aspect, and put on an air of civilization, since it became a receiver of western produce and exporter of goods. The steam tonnage multiplied to transport the growing produce of the west. In 1822 the Superior was launched, another steamer in 1824, two in 1825, and three in 1826. One of these made the first voyage upon Lake Michigan, in 1826, on a pleasure excursion. It was not until 1832 that business called them thither, and then one reached Chicago, in the employ of the government, to carry supplies for the Black Hawk war. From that time, tonnage has increased as follows:—

	1841.	1850.	1860.
Buffalo Creek	6,773	25,990	42,640
Presque Isle	2,813	5,691	1,471
Cuyahoga	1,855	6,418	22,597
Sandusky	..	..	360
Miami	887	1,745	..
Detroit	2,053	16,469	30,381
Mackinaw	..	1,746	617
Chicago	..	652	8,151
Milwaukee	..	..	2,026
	14,381	58,711	108,243

The 11 boats running in 1833, carried to and from Buffalo 61,485 passengers, and the fares with the freight amounted to $229,212. Those were the years of the great land speculations, and crowds of passengers went west on that errand. Three trips were made a year to the upper lakes. The trips to Chicago from Buffalo occupied 25 days to go and return. In 1841 the time required for a first-class steamer was 10 days from Buffalo to Detroit and back. This was reduced in 1851 to 3 days, and 5 for propellers. In 1834 the lake commerce was controlled by an association, owning 18 boats. This association was kept up to 1841, when the number of boats had increased to 48. The opening of the Ohio canals had poured upon the lakes a large amount of produce. The 500 miles of canal then completed, opened up the grain country to the lakes. In 1835, Ohio exported by the lakes 543,815 bushels of wheat; in 1840, 3,800,000 bushels; and in 1851, 12,193,202 bushels, which paid $500,000 freight and charges. The railroads have since interfered to some extent, but the wheat received across the lakes has this last year been as follows:—

From Ohio	2,856,216	bushels.
" Indiana	3,219,225	"
" Michigan	2,117,970	"
" Illinois	12,195,195	"
" Wisconsin	5,447,766	"
" New York	130,667	"
Total	25,967,039	"

The successive opening of the Ohio canals in 1833, the Illinois canal in 1848, and the Indiana canal in 1851, all added constantly to the amount of produce to be transported, and since the last-mentioned date the railroads have opened new regions of country, and increased the lake trade. It is to be borne in mind that the size of the vessels, their great speed when under way, and the greater dispatch in loading and unloading by steam, not only for motion, but for labor at the dock, enable the same quantity of tonnage to do ten times the business that it formerly could do. In 1859 the lake steamers averaged 437 tons. In the present year the average is 680 for steamers and 470 for propellers. A change is now going on in the power, by reason of the improvements in propellers. In 1843 the first lake propeller, the Hercules, was launched at Cleveland, 275 tons, the screw of Ericsson's patent. She was said to have made great economy in wood for fuel. In 1851 the propellers had increased to 52, with a tonnage amounting to 15,729. In 1860 there were 118, tonnage 55,657. These boats had far less speed than the paddles, but they have not ceased to gain in public opinion, not only upon the lakes, but in the Atlantic bays and rivers, until recent improvements have brought them to rival the paddle wheels in speed. These vessels will in all probability monopolize the European, as well as the internal trade.

Previous to the opening of the Erie canal, in 1825, the commerce of the lakes was necessarily local, since there were no markets east or west. The produce raised in the country bordering the lakes descended the streams that ran into them, and found interchange with other lake ports. The opening of the canal immediately gave an eastern current to produce of all descriptions, and much had ac-

cumulated in anticipation of the event, and goods returned in great quantities. In the month of May, 1825, 837 boats, carrying 4,122 tons of goods, left Albany for Buffalo, paying $22,000 tolls.

The lumber from western New York and the lake borders being now marketable where before it was valueless, a motive for clearing land was imparted, and the new canal received on its bosom from all sections of the lake shore the lumber brought by multiplying vessels. The lumber that found tide water before had been that which in southern New York and in Pennsylvania skirted the natural water-courses, and being cut and hauled, was rafted down to Philadelphia and Baltimore. The New England streams delivered the lumber in the same manner. The opening of the canal brought into competition the vast and hitherto untouched resources of the west, and the same remark applies to all farm produce. The farmers of New England were undersold at their own doors, by produce from western New York. The potatoes that had been quick of sale at 75 cents, were supplanted by the best "chenangos" at 37½ cents, and the competition was felt in corn, flour, and most articles. The effect of this was to turn the attention of that hard-working and thrifty race of men, the farmers of New England, to the western country, where the soil was so much more profitable. At that date commenced the interchange of inhabitants, which has drawn off so many New England farmers, replacing them with manufacturers from abroad. In order to show the extent of this operation, we take from the census of 1850 the figures showing the nativities of the whole people of the United States. Thus there were in the whole Union 8,370,089 persons who were born in the New England and middle states. Of these, 6,941,510 lived in the states where they were born. The remainder, 1,428,579, were living mostly west, but in their place there were living in the New England and middle states 1,292,241 persons who were born in foreign countries. These latter worked in the mills and manufactories, while 1,428,529 northern persons who had migrated west were agriculturists attracted thither by the fertile lands made available by the means of transportation. The lakes were now connected with tide water, but the whole system of western rivers with a southern course had no northern connection. The state of Ohio determined to make the connection, by means of a canal from Portsmouth, on the Ohio, to Cleveland, on Lake Erie. On the 4th July, 1825, the first spade was put into the ground, and in 1833 the first boat passed through from lake to river, 307 miles. The whole interior of Ohio was thus opened to either the northern or the southern market; and the state authorized turnpikes and other roads to feed the canal, on the borders of which trade grew rapidly. There are several branches of the Ohio canal; one, the Hocking, goes to Athens, and another to Columbus. The highest level of the Ohio canal is 305 feet above the lake, and 499 feet above the Ohio river. Another canal, the Miami, was also commenced in 1825 to connect Cincinnati with Lake Erie. In 1829 it had been opened to Dayton, 65 miles, but it was not completed until 1843, when it connected, 121 miles, with the Wabash canal, which joins Lake Erie at Toledo, making 215 miles from Cincinati to Lake Erie. All the Ohio canals are as follows:—

	Length. Miles.	Cost.
Ohio canal	340	$4,695,202 69
Miami	85	1,020,000 00
" extension	130	3,667,440 82
Muskingum	92	1,628,028 29
Hocking	56	975,481 01
Wabash and Erie	91	3,009,923 29
Walhonding	25	607,268 99
Total	819	$15,603,347 09

Thus Ohio was crossed by canals, that gave the greatest development to her resources, and a new route was opened for all the western waters to the Atlantic; an interior transit from the Atlantic cities to all those of the east was in operation; and New Orleans might now be reached from New York and New England, by an internal route, with comparative ease and safety.

The state of Pennsylvania next undertook the great work of forming a connection between the Delaware and the Ohio. The project which had been formed at the close of the last century was now resumed; and in 1826 a law was passed to construct the work at the expense of the state, and, July 4th, 1826, the first earth was turned at Harrisburg, and in 1834 it was opened for use. The line consisted of a railroad, 82 miles, from Philadelphia to Columbia, cost $3,330,127; a canal from Columbia, 172 miles, to Hollidaysburg, cost $4,594,146;

a portage railroad across the mountain from Hollidaysburg to Johnstown, 36 miles, cost $1,634,357; and a canal from Johnstown to Pittsburg, 105 miles, cost $2,823,192—making 395 miles, at a cost of $12,381,822. Thus the Ohio at Pittsburg was now connected with Philadelphia, by a route much less than from Buffalo to New York. There were seven branch canals made to feed this. The aggregate length was 314 miles, and the cost $6,471,994. Every part of the state was now more or less in communication with the great outlets east and west. There were, besides, three private canals, viz.: the Schuylkill, 108 miles; the Lehigh, 85 miles; and the Union, 82 miles, which connected the great coal fields with tide water.

We have shown that Washington presided, at the close of the Revolution, at a meeting for the improvement of the Potomac. The ideas then suggested ripened into a project for a canal. The cession of a portion of Maryland and of Virginia to form the District of Columbia as a seat of government led to the national desire to connect it with the west. This was done, as we have seen, by the National or Cumberland road to Wheeling. But in 1820 the canal from Georgetown to Pittsburg was projected, Congress voting $1,000,000. Washington City issued bonds for a like sum. Georgetown and Alexandria each subscribed $250,000, Maryland $500,000, and Virginia $250,000, and 6,084 shares of $100 each were taken by individuals, making altogether $3,854,400. As the work was to run through four territories, it required a charter from Congress, Maryland, Virginia, and Pennsylvania, and July 4th (Fourth of July is a great day for canals), 1828, John Q. Adams and Charles Carroll turned the first earth. In 1834, 104 miles had been completed. The work was finally carried 191 miles to Cumberland in 1840, at an expense of some $16,000,000. It will not probably be carried further, never having answered expectations, although of late it has had business from the Cumberland coal regions.

Thus of the three great projects for connecting the eastern and western waters, only two were carried out. But, following the example of Ohio, both Indiana and Illinois determined to make a connection across their respective states, between the rivers on the south and the lakes on the north. But they were some years later than Ohio, since they were younger and weaker states. In 1836, under the spur of the speculative fever, Indiana enacted a bill authorizing a system of internal improvements. This embraced the Wabash and Erie canal, to run from Evansville on the Ohio to the Ohio state line, where it was to follow down the valley of the Maumee, taking up the Miami canal in its course, and entering the Erie Lake at Toledo. Second, the White Water canal, to connect the National or Cumberland road at Cambridge, with Laurensburg on the Ohio, 76 miles. Third, the White River canal, to connect Indianapolis with Evansville on the Ohio, 190 miles, and to prolong it from Indianapolis to Peru on the Wabash canal. There were also to be some Macadam roads and turnpikes. These works were to cost $10,000,000. The Wabash canal was begun in 1835, and in 1840, 90 miles were finished. The great revulsion then brought all to a stand, and some ten years elapsed before the work was completed through the aid of a loan obtained on pledge of lands granted by Congress in aid of this work.

The state of Illinois undertook a far more extensive system of public improvements. As early as 1810 a project was put forward, under the excitement of Fulton's great success, to connect New Orleans with Buffalo in 32 days by steam, *via* what is now Chicago. The waters of the Illinois and the lakes were in high floods nearly blended. In 1823 a board of commissioners was appointed to report on the route and the cost. A grant of land was obtained from Congress in 1829 in aid. This was every alternate section of land, 10 miles on each side of the canal, in its whole length. Not until 1835 was an act passed to authorize the canal, in common with many other works, railroads or others, in a general system of internal improvements, which were to cost $12,000,000, and there had been sold of the lands granted by Congress $1,395,911.

The canal was to connect Chicago, at the foot of Lake Michigan, with the Illinois river, 102 miles. It was prosecuted with more or less vigor until the finances and credit of the state were ruined by the revulsion of 1837–9. The work then lay unfinished until in 1843, by means of a pledge of the unsold lands of the canal, a sum of $1,600,000 was borrowed, and the work completed in 1852. The sales of the land sufficed to pay off the new loan and some of the arrears.

We have thus sketched the great main canal avenues that connect important sections, and may enumerate them as follows:—

		Miles.	Expenditure.	Width. Feet.	No. of Locks.
Erie canal	Hudson river to lakes	363	$7,143,789	40	84
Pennsylvania canal	Delaware and Ohio	395	12,381,822	40	200
Ohio "	Ohio river and Lake Erie	307	4,695,824	40	152
Miami "	" " "	178	3,750,000	40	102
Indiana "	" " "	379	7,101,000	60	102
Illinois "	Lake Michigan with Illinois river	102	8,654,337	60	2
Total		1,724	$43,726,772		

The financial results of the New York canals may be thus stated in the aggregate of receipts and revenues from the commencement of the works to Sept. 30, 1859:—

Receipts.		Expenditures.	
Gross tolls	$70,565,737	Construction	$55,106,814
Loans	55,842,462	Repairs	16,932,080
Other items	20,469,924	Loans and interest	57,028,943
		Other items	17,790,286
Total	$146,858,123	Total	$146,858,123

These great state works have completed the connection between the Atlantic, the lakes, and the western rivers, and, by so doing, have promoted the circulation of the produce of all sections in active competition. The resources of every section have been drawn out in such a manner that the whole people have had the advantages of all. In the course of the development a vast capital was added to the national wealth, and a great value bestowed upon land not before very marketable. While this has been done by state means, a great number of other canals have been erected as well by public means as private enterprise. The most important of these was the Delaware and Raritan canal, connecting those two rivers. The work was completed in 1827, shortening the distance 16 miles between Philadelphia and New York, and packet propellers run regularly through it between the two cities. It is also the main source of supply of coal for New York. The state of Virginia early embarked in improvements, particularly in the James river, which is navigable to Richmond for vessels of 120 tons, the tide reaching there; above Richmond a series of short canals intended to connect the river with the Kanawha, where it is navigable 70 miles from its mouth on the Ohio. This project was undertaken by the James River and Kanawha Company, and was completed in the form of a canal, 147 miles, at a cost of $5,020,050. There are many other works of public utility in Virginia, under the control of a board of public works, chartered in 1816. There are a number of other canals in several states, as the Blackstone, of Massachusetts; the Ogeechee, of South Carolina, connecting Charleston with the Santee, cost $650,667, and many other improvements in a number of states. The Morris and Essex canal, of New Jersey, 101 miles, was completed in 1831. It had banking powers connected with it, and of all the public works in the country was the basis of the most stupendous stock speculation. Its liabilities were at one time near $10,000,000, and it was sold out in 1845 for a sum less than $3,000,000; its business is at present prosperous. It is one of the works that were erected to develop the great coal business of Pennsylvania. The discovery of that important mineral takes date about the year 1820, and the canals that were built to bring the coal down may be enumerated as follows:—

		Length. Miles.	Cost.	Width.	Locks.
Schuylkill navigation	Pennsylvania	108	$2,500,196	36	120
Lehigh canal	"	85	4,455,099	60	81
Susquehanna	"	41	897,160	40	12
North Branch	"	73	1,590,379	40	8
" " upper	"	94	4,500,000	40	..
Union	"	82	5,000,000	36	90
Delaware and Hudson	New York	108	9,100,000	75	18
Morris canal	New Jersey	102	3,612,000	32	29
				planes,	22
Total canals		693	$31,654,834		

The expenditure of large sums of money along the routes of these works for their construction promoted a local demand for produce, and aided in the settlement of the

country through which they ran, and from the improvement of which their future freightings were to be derived, and there is little matter of surprise that the first years of their operation should be of large promise. The cost of transporting a ton of merchandise from Buffalo to Albany, which had been $100, and the time twenty days, was at once reduced to $20, and the time to eight days. While yet they were being constructed, however, a new agent of transportation had risen, which was to overshadow their importance, and reduce them to a second rank. The rejoicing for the completion of the Erie had hardly died away, before the locomotive began to throw its shadow on the future. The "astonishing speed" of steamboats and stages was about to dwindle into an intolerable tedium. The capacities of railroads had begun to be discussed, and the discussion rapidly elicited action, which did not cease to extend itself, until the whole country has become covered with rails. When railroads began to be constructed, however, both vehicles, sailing vessels, and steamers had made considerable progress in speed, and the connections of travel had come to be made with more regard to dispatch. It is amusing to look back at some of the accounts of the wonders of the canals after the opening. Thus, in 1823 it is stated—

"CANALS! A *sloop*, called the Gleaner, has arrived at New York from St. Albans, in the state of Vermont, with a cargo consisting of 1,200 bushels of wheat and other articles. She will carry sixty tons of merchandise, and does not appear to have had any difficulty in passing through the northern canal. It is supposed that she will safely navigate the Hudson, and she is designed as a *regular packet* between St. Albans and the city of New York. *Look at the map!* An uninterrupted *sloop navigation* from one place to the other!

"When the Green Mountain vessel arrived at New York, the veteran artillery were ordered out, and she was saluted from the battery."

In 1824. "INTERNAL IMPROVEMENT. It is stated in one of the New York papers that a barrel of flour can be transported from Albany to New York, a distance of 150 miles, for 12½ cents, and that one individual offers to do it for seven cents."

In 1825. "MARCH OF INTELLECT WITH POWER.—It is no fairy tale, that flour, *manufactured on Lake Erie*, has been profitably sold in Newbern, *North Carolina*, for $5.50 per barrel. This flour was transported from the lake to Albany, through the Grand canal; thence down the North River to New York; and thence, by sea, to Newbern. The cost of transportation from the lakes to Newbern was less than $1.50 per barrel, while that between Raleigh and Newbern (not more than 120 miles) is generally two dollars."

In 1826. "The following, from the *Pittsburg Gazette*, shows the importance of canals. Mr. Foster has published in the *Greensburgh Gazette* a statement furnished him by a merchant of Meadville, showing the amount which the merchant paid for the transportation of his goods this fall from Philadelphia, *by way of New York*, the canal, and Erie, to the town of Meadville. The whole cost per hundred pounds was $1.20½! *We are now paying three dollars per hundred for carriage in wagons from Philadelphia to this city!*"

These extracts afford—in contrasting not only the routes, but the prices, with those before their use and those which now exist—much room for reflection. It may be remarked that the Caroline, burnt in the employ of the sympathizers in 1839, at Schlosser, and sent over the falls of Niagara, was built in South Carolina, and had passed up the canals to her destination.

CHAPTER III.

RAILROADS—LAND GRANTS—EXTENT AND COST.

THE excitement in relation to canals and steamboats was yet at its zenith, when the air began to be filled with rumors of the new application of steam to land carriages and to railroads. There were many inventions and patents at home and abroad in relation to carriages propelled upon common roads by steam, but these seem never to have attained much success, although attempts to perfect them are still made with great perseverance. On the other hand, the use of railroads from small beginnings has reached a magnitude which overshadows the wildest imaginings of the most sanguine. In 1825 descriptions came across the water of the great success of the Darlington railroad, which was opened to supply London with coal, and which had passenger cars moved by steam at the rate of seven miles per hour.

The most animated controversy sprang up in relation to the possibility of such roads in England, and were shared in to some extent on this side of the Atlantic. With the national energy of character, the idea had no sooner become disseminated than it was acted upon. The construction of railroads in America is usually ascribed to the emulation excited by the success of the Liverpool and Manchester railway. This appears not to have been the case, however, since some of the most important works in this country were projected and commenced before the Liverpool and Manchester road was built. The act of Parliament for the construction of that road was passed in 1826, and the road itself was finished and opened in September, 1830, 31 miles long; but the Massachusetts Quincy road, three miles from Quincy to Neponset, was opened in 1827, and a great celebration was held in consequence. The celebrated Mauch Chunk railroad of Pennsylvania was begun in 1826, and finished in the following year. On that road the horses which draw up the empty coal wagons are sent down on the cars which descend by their own gravity. This contrivance was borrowed from the Mauch Chunk road by the Darlington road, similarly situated, in England. It is to be remarked that both the Quincy and the Mauch Chunk roads are horse roads; the locomotive was not at first introduced. In 1828, twelve miles of the Baltimore and Ohio railroad were completed, two years before the Manchester road was opened. In the same year, 1828, the South Carolina road, from Charleston to Hamburg, was surveyed, and in Massachusetts the city of Boston voted the construction of a road from that city to the Hudson at Albany. The first portion of that road, however, Boston to Worcester, 44 miles, was not opened until 1835. The second road finished in the United States was the Richmond, Va., road, thirteen miles to Chesterfield, in 1831, and in the same year that running from New Orleans, five miles to Lake Pontchartrain, was opened. Thus roads were well adopted in public opinion here before the great success of the Manchester road was known, but which gave an undoubted impulse to the fever. During the excitement in relation to "rail" roads, a writer in a Providence paper thus satirized the condition of the Connecticut roads. He claimed the invention of the cheapest "rail" roads, and proved it thus: "Only *one* English engine *alone* costs $2,000, which sum the whole of our apparatus does not much exceed, as figures will prove; for 700 good chestnut rails at $3, amounts to only $21, and it ought to be remembered that this is *all* the expense we are at, and the inference is conclusive in our favor. We place our rails fifty to the mile by the side of the road, to pry out the wheels when they get stuck, and hoist behind when wanted." The public were, however, no longer to be satisfied with this kind of "rail" road. They embarked in the new enterprise with such vigor, that in 1836 two hundred companies had been organized, and 1,003½ miles were opened in eleven states. These were highly speculative years, however, and the revulsion brought matters to a stand.

It was at once apparent to the commercial mind that if railroads would perform what was promised for them, geographical position was no longer important to a city. In other words, that railroads would bring Boston into as intimate connection with every part of the interior as New York could be. The large water communication that enabled New York by means of steamboats to concentrate trade from all quarters, could not now compete with the rails that would confer as great advantages upon Boston. Indeed, Boston had now availed herself of steam power. Up to 1828 she owned no steamers. The Benjamin Franklin, built in that year, was the first, and her steam tonnage is now but 9,998 tons. When she bought her first steamboat, however, she was laying out those railroad connections that she has since pushed so vigorously, and they have paid an enormous interest, if not directly to the builders, at least to the general interests of the city.

It is to be remarked that the national government expended, as we have seen, largely in the construction of highways, the clearing out of rivers, and the improvement of harbors. The people have by individual taxes mostly constructed the earth roads of this country. The canals have, however, with a few exceptions, been state works, built by the proceeds of state loans, with the aid of lands donated by the federal government. These lands were made marketable and valuable by the action of the canals in aid of which they were granted. The railroads of the country have been, as a whole, built on a different plan, viz., by corporations, or chartered companies of individuals. These

associations have not, however, themselves subscribed the whole of the money, probably not more than half, but they have found it to their interest to borrow the money on mortgage of the works. The great object of the companies has not been so much to derive a direct profit from the investment, as to cause the construction of a highway, which should by its operation increase business, enhance the value of property, and swell the floating capital of the country by making available considerable productions of industry, which before were not marketable, since the influence of a railroad in a new district is perhaps, if not to create, at least to bring into the general stock more capital than is absorbed in its construction.

Thus in the last twenty-five years, a thousand millions of dollars have been spent in the construction of roads, and yet capital is proportionally more abundant now than before this vast expenditure, and land has, in railroad localities, increased by a money value greater than the cost of the roads! We have seen that before the operation of canals, land transportation was, and is now, remote from these works, one cent per mile per hundred. If a barrel of flour is then worth in market five dollars, a transportation of 300 miles would cost more than its whole value; but by rail it may be carried from Cincinnati to New York for one dollar. Thus rails give circulation to all the surplus capital that is created by labor within that circle. It is on this principle that may be explained the immense prosperity that has been seen to attend the enormous expenditure for railroads, particularly during the last ten years.

The construction of the Massachusetts Western railway, from Boston to the Hudson river, was one of the most important and financially successful of all the railroads of the country. New York had constructed her great canal, as it were making Albany basin a part of Lake Erie. Boston now grasped the idea of a railroad that should make Albany basin with its affluents a part of Boston harbor. It is to be borne in mind, however, that when that road was undertaken, railroad building was a new art; the mode of laying the track, the form, and even the model of rails were problems. The form of wheels to run on the rails, the mode of setting the car on the wheels, were all unknown compared with the knowledge on the subject which the construction of 30,000 miles of roads in this country has since accumulated. The state of knowledge at that time may be seen in the following extract from "Wood on Railroads" in 1825:—

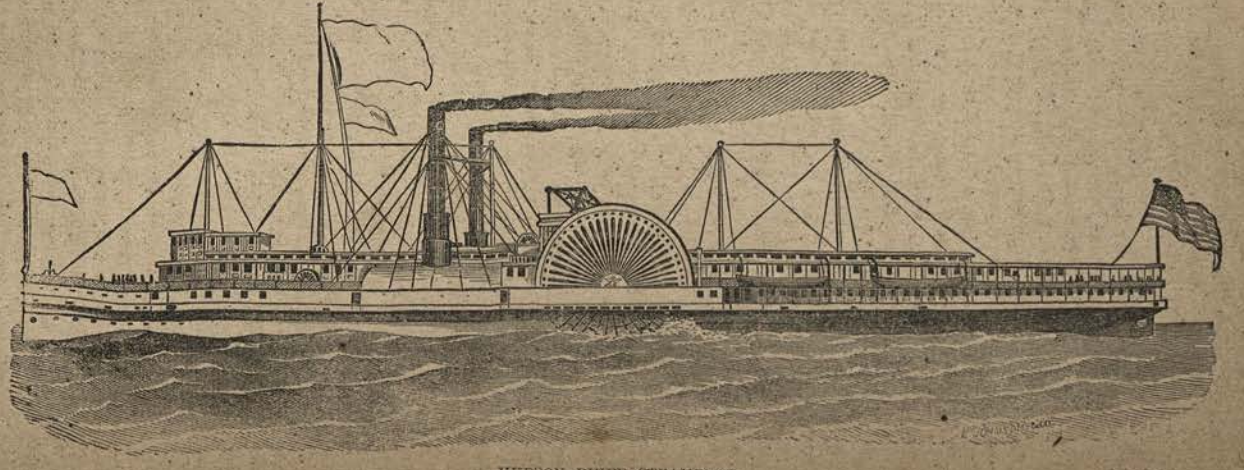
"Nothing can do more harm to the adoption of railroads than the promulgation of such *nonsense* as that we shall see locomotive engines travelling at the rate of twelve miles per hour."

Such was engineering knowledge at the time Boston voted to build a connection 200 miles to Albany. Since that day much has been learned in relation to the characteristics of roads.

The great advantage of railroads is that they practically diminish distances between places in proportion to the speed attained. The rapidity of motion and power of traction depend upon the diminution of friction. This was sought in common roads, Macadam roads, and canals, but has approached perfection in railroads. The essential attributes are two smooth surfaces for wheels to run on. These being made of iron, are made as narrow as possible to lessen the cost; and to keep the wheels upon the rails, flanges are placed upon the inner rim of the wheel. The form of the iron rails has undergone many changes, as experience suggested improvements. The mode of laying these has also varied. The building of a railroad includes "the road bed," somewhat like a common road, and the superstructure, which embraces rails, supports, ties, etc. The main operations in the construction of the road bed consist in the "excavations, tunnels, embankments, ballasting, bridges, and viaducts."

These operations are required to give the necessary levelness and straightness to roads, both of which are requisite, not only as elements of speed, but of economy. The straightest road is the shortest; but when the road is done, the expense of keeping up the earth-work is nearly nothing, while, on the other hand, the annual expense required to keep up the perishable superstructure is very great and proportionate to the length of the road. Hence true economy requires a greater outlay to make the road straight, in order to avoid permanent cause of expense. Common roads may be lengthened to advantage, in order to avoid an ascent. In railroads this is avoided by tunnels through the obstacle when it is too high to excavate at what it would cost to tunnel. This is not, however, the only reason for straightening, since the frequency of curves greatly increases the danger of railroads.

FIRST LOCOMOTIVE EVER RUN ON THE MOHAWK VALLEY RAILROAD.



HUDSON RIVER STEAMBOAT.

When a car in motion enters upon a curve, it has a tendency to continue its straight course, and this is overcome by the resistance of the flanges of the wheel against the rail, and by the firmness of the outer rail. This resistance is always felt in the rocking motion of the cars, and is increased by the shortness of the curve. A pair of wheels is fastened to an axle and turns with it, the outer wheel moving on a curve much faster than the inner one, which would slide, under such circumstances, if both were of the same diameter, sufficiently to make up the difference. This is obviated by making the wheels conical, or of a larger diameter next to the flange than on the outside. The effect of this is that the wheels having some play between the rails, the outer wheel, forced against the rail, runs on a larger diameter than the inner one, thus compensating the speed. Further, to overcome the centrifugal force, the outer rail is made higher than the inner one, so that the weight of the car gives it a tendency to slide toward the inner one in opposition to the centrifugal force. The excavations in loose earth require to be supported at the sides by retaining walls, and to be drained by ditches and cross drains. In making a tunnel the centre of the road is set with great accuracy on the surface of the ground by an instrument, and shafts are sunk at proper levels along this line. The excavations are then made by "drifts" from shaft to shaft, and to the open ends of the tunnel. The material excavated is raised through the shafts, which serve for ventilation when the tunnel is finished. The embankments require great care to insure their solidity. When the materials for filling are at hand, they are usually made at their full height at one end, and then temporary rails permit the approach of wagons to be emptied over the head of the embankment. The progress of the work depends upon the speed with which these succeed each other. When the track passes through a country like a wooded swamp, where the materials for filling are not at hand, resort is had to trusses. Piles of a diameter of 15 inches are driven, so as to form lines of the width of the railroad; transverse ties are fastened across the tops, and, with proper supports, longitudinal timbers are laid across the piles to carry the rails. The tops of embankments and the bottoms of excavations are made about two feet below the intended or "formation level" of the road, and have there a convex surface like an ordinary road. This space of two feet is filled up with porous material, broken stones, gravel, etc. This is called "ballast," and through it the rains pass freely, and the frosts of winter do not so much affect it. On this "ballast" the rails are laid. Many roads are not properly ballasted, and are, therefore, unsafe. Bridges are difficult of construction, and have sometimes been made of iron. This was the case with the Erie railroad, when an accident occurred, because the iron, resting upon stone piers, contracted by the cold so as to drop off its support.

When the road bed is complete, the superstructure is put on. This is now done by cross sleepers. The best of these are second-growth chestnut, 7 feet long, and 8 by 12 inches. These are laid upon the ballast. The iron rails are laid upon these, but in some cases longitudinal timbers are first laid down, and upon these the iron rails are laid. The iron rails have undergone many improvements. At first, a simple flat iron rail was spiked down to these timbers. These rails would often get loose, and the end rising form a "snake head," and the wheel catching under, throw it up with great force and danger to passengers. These roads were ridiculed as "hoops tacked to a lath." Various forms and weights of rail were adopted as experience directed; that now the favorite is called the T rail; the shape is like that letter inverted. There must be a certain breadth of rail for the wheel to run on, and depth for strength. The smallest rails will weigh 36 lbs. to the running yard. The Massachusetts roads use 60 lbs. to the yard; the New York roads, 70 to 75 lbs. to the yard. The rail is not fastened directly to the timber, but is held in chairs, which are spiked to the cross sleepers. The chair is of cast or wrought iron, and will weigh 20 to 30 lbs. They are made in one piece, so as to receive the ends of two rails, which are fastened by wedges of iron or wood, driven between them and the chair, without interfering with the longitudinal expansion and contraction of the rails.

The proper breadth of rails apart, or the width of the track, has been matter of much discussion. There are many advocates of the "broad gauge" and of the "narrow gauge." The latter is generally 4 ft. 8 in. and the former 6 ft. The Erie railroad is of the broad gauge, and the convenience of the cars is superior to that of the narrow

roads. It is a more expensive road to build, however. Both plans have their advantages. The majority of roads are, however, built on the narrow gauge. When gauges on long lines are uniform it facilitates the passage of the cars, which would otherwise be interrupted.

The power on railroads is mostly steam, but horses, stationary engines, and atmospheric pressure are sometimes used. The first really successful locomotive was built in 1814, which drew 30 tons 6 miles per hour; improvements have since been made until 70 miles per hour is attained. A Philadelphia engine drew 158 cars, 2,020 feet long, with 1,268 tons coal, 84 miles in 8 hours. The engine weighed 15¾ tons. The power of an engine depends upon the quantity of steam it can generate in a given time. Each revolution of the wheels corresponds to a double stroke of each piston, or four cylinderfuls of steam. The utmost heating surface is therefore required, and this is obtained by tubular boilers. Wheels, 7 feet in diameter, pass over 22 feet in each complete revolution. To go 25 miles per hour, therefore, they must revolve five times in a second, and each piston must make 10 strokes in the same time. This minute division of time is accurately made by this ponderous machine. This rapid exhaustion of steam causes a greater demand for fuel in proportion to the speed. The power of an engine to draw loads depends upon the pressure of steam, which is usually 50 to 60 lbs. to the square inch; but the adhesion of the engine to the rails must be great, otherwise the wheel would slip round. For this reason the wheels were first made with cogs to hold in the rail, but it was found that the weight of the engine was sufficient on level roads. The adhesion of iron upon iron is one-eighth of the weight, but in wet and freezing weather it is greatly reduced, and it lessens with the increase of the slope of the road, or ascending grade. Thus, if an engine will draw 389 tons on a level, it will draw but one-fourth of the amount up a grade 50 ft. to the mile. The average cost of locomotive power is not far from 50 cents per mile run, which includes fuel, oil, wages, repairs, wear and tear, etc. These expenses are, of course, lessened by levelness and straightness, since where these are perfect, more is carried for the same money, than on common roads. A great draw-back upon the cheapness of rail transportation is the weight of the rolling stock. The cars and engines usually are to the paying freight as 10 to 6. Various means have been proposed to lessen the burden of this expense, but hitherto without much success. It is evident from this slight sketch of the principles of railroad construction that the characteristics of a road, in relation to curves, grades, etc., have much to do with the economy with which it can be run, and its capacity to compete successfully with rival lines.

The city of Boston was, as we have said, one of the earliest to understand the advantages that were to be drawn from railroads in overcoming the disadvantages of its position in relation to the west, and the Western railroad has been the instrument by which she made the great states west of New York subservient to her interests. The charter of that road is dated March 15, 1833. The road runs from Worcester, 44 miles west of Boston, to the Massachusetts state line, and thence 38¼ miles over the Albany and West Stockbridge railroad, leased and operated by the Western road, into Albany, 200 miles from Boston. The first train of passengers that left Boston was on April 7, 1834, for Davis' Tavern, Newton, to which place the Worcester road was then opened. It was completed to Worcester July 3, 1835. The Western road, in continuation, was opened to Springfield Oct. 1, 1839, ten days before the United States Bank finally failed, and it reached Greenbush Dec. 21, 1841, thus establishing the route from Boston to the Albany basin in seven hours. It there connects with the New York Central road, which carries the line 229 miles to Rochester, whence, by the Lockport division of the Central road, 77 miles, it connects at Suspension bridge with the Great Western Canada road, and thence with the Michigan Central, the Illinois Central, and the Ohio and Mississippi roads to New Orleans. By this route Boston and St. Louis, 1,365 miles distant, are connected in 64 hours. From Buffalo the line connects south of the lakes with all the net-work of Ohio and other roads. Every portion of the country is thus brought into connection with Boston.

The Worcester railroad has a double track its entire length, laid with 60 lb. iron. Its freight-house at Boston is a single room 466 feet in length and 120 feet wide. The cost of the road was $4,843,610. The Western has a double track 18 miles; it has 20 depots, covering 118 acres of land; it has 15 stone-arched bridges, 15 to 60 feet span.

The bridge across the Connecticut is 1,264 feet long. The Western road has a grade of from 60 to 80 feet per mile for more than 18 miles; near the state line the depot is 1,456 feet above the depot in Boston! These features indicate the difficulties that were encountered in the construction, and it received much aid from the state. The original capital was $2,000,000; in 1836 this was increased, and the state subscribed $1,000,000. The state subsequently loaned its credit for $4,000,000. The present debt of the company is $5,839,080, and the capital $5,150,000, on which it uniformly pays 8 per cent. dividend. The cost of the Western road proper was $6,757,309, and of the Albany and West Stockbridge, $2,392,384. The opening of this road made a great change in flour business. Formerly the flour that came down the Erie canal, and was transhipped in sloops, made the voyage up the Sound and round Cape Cod, into Boston harbor. The Western road made the line direct, and by it about 600,000 bbls. now annually leave Albany; of this 40 per cent. is sold along the line, in what was once an agricultural region, and the balance meets in the Boston market the flour of the southern states. The Boston and Providence road was opened 41 miles in June, 1835, and at once became the connecting link between the steamboats from New York and Boston, taking the place of the stage lines. This road has now several branches, and has been very profitable. The original cost, $3,862,710, has long since been returned to its stockholders in 6 per cent. dividends. It has a debt of $195,220, which is paid at the rate of $30,000 per annum.

The Boston and Maine road, which is the second link in the great chain which reaches from Bangor to New Orleans by the Atlantic coast, 1,996 miles, was opened in 1843. It runs 74 miles to Berwick, where it connects with the Portland, Saco, and Portsmouth, extending to Portland. The cost of this has been $4,719,995, and it has no debt. It has, since Oct., 1838, paid 40 dividends, amounting to $133 per share of $100. The connections of this road are very numerous. Lateral and cross roads bring every manufacturing town in New England within easy distance of Boston. The 3,749 miles of railroad in the New England states give an active circulation to raw materials and the products of industry, making, so to speak, all the labor of those states available on equal terms.

In New York the question of railroads had been very early discussed. A publication of Colonel Stevens, of Hoboken, in 1812, advocated a railway instead of a canal to the lakes; but his proposition was opposed by Chancellor Livingston on grounds which indicate very odd ideas of the nature of the works. The first regular application to the legislature for a railroad charter seems to have been made by Stephen Van Rensselaer and others in 1826, for power to construct one between the Hudson and the Mohawk, and they received the grant for the reason that no railroads were then in the country at all, and that, as the petitioners were willing to make the experiment at their own cost, it was a good opportunity to permit it. The surveys for the road were not made until 1830, and the road was opened in September, 1831, and three cars, with twenty passengers in each, were drawn to Schenectady in 46 minutes by an American engine of 3½ tons. Meantime, the charters of the Harlem and the Saratoga and Schenectady had been granted. The opening of the Mohawk road caused much excitement. A road from the Hudson to the lakes was agitated, and applications were made to the legislature of 1832 for 49 roads, of which 27 charters were granted, and of these 27 six were constructed, viz.: the Brooklyn and Jamaica, Hudson and Berkshire, Erie, Rensselaer and Saratoga, Tonawanda, Watertown and Rome. In 1833, six railroads were chartered; of these the Utica and Schenectady, Whitehall and Rutland, and Buffalo and Black Rock were constructed. In 1834, ten railroads were chartered, and of these five were constructed: the Auburn and Syracuse, Buffalo and Niagara Falls, Long Island, Lockport and Niagara, and the Saratoga and Washington. In 1836, 43 railroads were chartered, seven of which were built: the Albany and West Stockbridge, Attica and Buffalo, Auburn and Rochester, Lewiston, Schenectady and Troy, Skaneateles, and Syracuse and Utica. In 1837, 14 railroads were chartered, but none of them have been constructed. In 1838, the state authorized a loan of its credit to the extent of $3,000,000 to the Erie railroad, and of $100,000 to the Catskill and Canajoharie, and of $250,000 to the Ithaca and Owego; also, $200,000 to the Auburn and Syracuse. In 1839, the Oswego and Syracuse railroad was chartered; and the city of Albany lent $400,000 to the Albany and West Stock-

bridge road. In 1840, acts were passed in the legislature to loan the credit of the state to the extent of $3,478,000 to six roads, and provision was made for a sinking fund to be paid into the treasury by the railroad companies, except the Erie. In 1841, the city of Albany was authorized to invest $350,000 in the Albany and West Stockbridge road. The Erie railroad, having defaulted on its interest, was advertised for sale by the comptroller, which did not take place, however. This was not the case with the Ithaca and Owego, which was sold for $4,500, and the Catskill and Canajoharie for $11,600. The loss to the state was $1,026,327. In 1844, the several railroads from Albany to Buffalo were, for the first time, permitted to transport freight on the closing of the canal, by paying the state the same toll as the canal would have paid. In 1846, the Hudson River and the New York and New Haven were chartered. In 1847, the seven roads making the line from Albany to the lakes were required to lay down an iron rail of 56 lbs. to the yard. They were likewise authorized to carry freight all the year by paying canal tolls; and all the railroads were made liable for damages in case of death by neglect of the companies' agents. In 1848, the general railroad law was passed. The law provides, however, that the legislature shall decide whether the "public utility" of the road justifies the taking of private property. This was removed in 1849. Thus, from 1826 to 1850, 151 charters were granted, and of these 30 have been carried into effect. We observe that the line from Albany to Buffalo was composed of seven distinct companies, finished at different times. Most of these were restricted as to fares. The Mohawk and Hudson—or Albany and Schenectady—was not restrained. The others were, as in the following table composing the line now known as the Central railroad:—

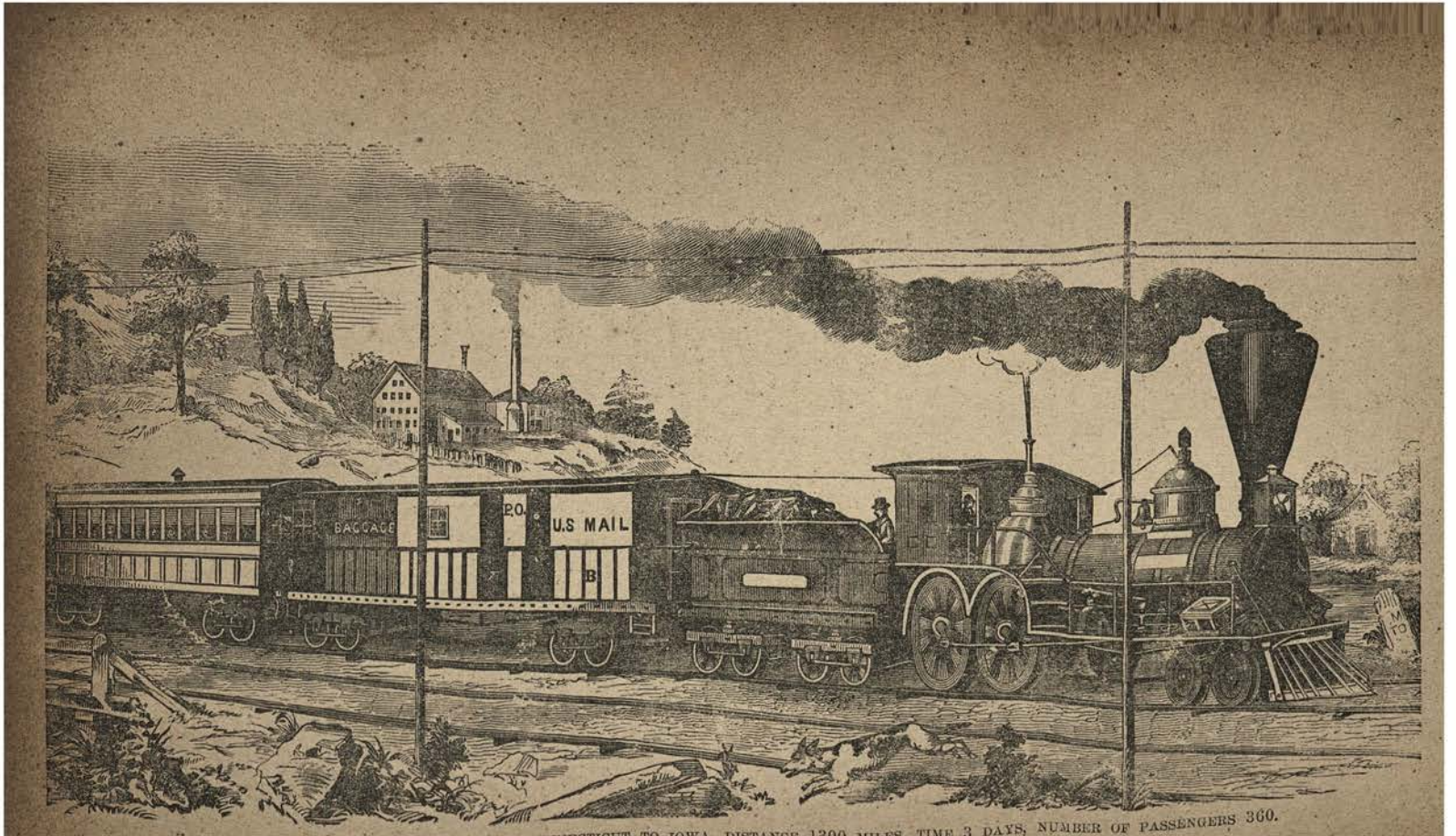
	Chartered.	Opened.	Maximum fare per mile.	Length. Miles.	Cost.
Albany and Schenectady	1826	1831	..	17	$1,711,412
Utica and Schenectady	1833	1836	.4	78	4,143,918
Syracuse and Utica	1836	1839	.4	53	2,490,083
Auburn and Syracuse	1834	1839	.5	26	1,011,000
Auburn and Rochester	1836	1841	.4	78	4,210,101
Tonawanda	1832	1842	.4	42½	1,216,820
Attica and Buffalo	1836	1842	.3	31½	906,915
Total				327	$15,690,249

These companies were in 1850 allowed to carry freight without the imposition of the canal tolls, and in 1853 were all consolidated in a single company—the New York Central. When this project of consolidating was under consideration, the stocks rose rapidly to high premiums, and the principle of consolidation was to create scrip stock to the amount of the aggregate premiums, and divide this *pro rata* among the stockholders of all the companies. That scrip, to the amount of about $8,100,000, now figures as a part of the cost of the present company. It may be remarked that the restrictions as to charge have been inoperative, since the charge has always been less. The length has been shortened in such a manner that the distance is now 298 miles from Albany to Buffalo, and the charge is $7.00, or 2½ cents per mile, the time being 14 hours. The capital of the company is $24,153,000, the liabilities $6,233,000, and the $8,100,000 debt certificates to be paid out of future income—making altogether $38,483,000, against $30,732,517, the cost of the roads. The business of the new company from its consolidation has been as follows:—

EARNINGS FROM PASSENGERS, FREIGHT, AND ALL OTHER SOURCES, FOR THE YEARS ENDING SEPT. 30, 1853–1859.

Years ending	Passengers.	Freight.	Other sources.	Total.
Sept. 30, 1853,	$2,829,668	$1,835,572	$122,279	$4,787,519
" 1854,	3,151,513	2,479,820	286,999	5,918,332
" 1855,	3,242,229	3,189,602	131,749	6,563,580
" 1856,	3,207,378	4,328,041	171,928	7,707,347
" 1857,	3,147,636	4,559,275	320,338	8,027,259
" 1858,	2,532,646	3,700,279	295,495	6,528,412
" 1859,	2,566,369	3,337,148	297,330	6,200,848
Total				$45,733,296

Whoever glances at the map of New York will observe that the Erie canal runs mostly through the northern counties, skirting, as it were, Lake Ontario for a considerable distance; that the lateral canals extend from this toward the southern portion of the state. The Chenango canal connects the Mohawk with the Susquehanna, and the Genesee Valley canal extends from the Alleghany river to Lake Ontario. The great southern tier of counties bordering on northern Pennsylvania, after having taken great interest in the construction of the canal, were without means of communication with markets, other than by common roads. The face of the country was too rugged to permit of a canal, but in 1825 the state legislature ordered the survey of a state road from Lake Erie to the Hudson river. Several conventions were held during the four years ending with 1830 in relation to the road. The railroad fever had gained ground meantime, and finally, in 1832, a charter for a railroad was granted,



MIGRATING AT THE PRESENT TIME FROM CONNECTICUT TO IOWA, DISTANCE 1300 MILES, TIME 3 DAYS, NUMBER OF PASSENGERS 360.

EMIGRATING FROM CONNECTICUT TO EASTERN OHIO IN 1805, DISTANCE 600 MILES, TIME 90 DAYS, NUMBER OF PASSENGERS 10.

with a capital of $10,000,000. The survey was made by De Witt Clinton, Jr., but the legislature required that $1,000,000 of the capital should be subscribed before the work was commenced. This was subscribed, and E. Lord chosen president in 1833. A new survey was made at the expense of the state, and the report made on it in 1835, when a reorganization of the company took place, with J. G. King president. The subscription of capital now reached $2,362,100. The work was commenced by putting 40 miles along the Delaware river under contract. The great fire of December, 1835, incapacitated many of the subscribers from paying up, and work was suspended. In January, 1836, the legislature loaned its credit for $3,000,000, but the stock could not then be negotiated. Some work was done along the line, however, by local subscription. In 1840—Mr. Lord again president—the loan act was amended so as to be available, and the company purchased its iron. The terms of the loan permitted the state officer to deliver to the company $100,000 of state stock whenever he should have evidence that the company had expended an equal amount; the state stock not to be sold under par. The company then paid its contractors with time drafts. The receipts for these drafts furnished the evidence of the company's expenditure, on which the state officer issued the stock to the company, which then borrowed on it the money to take up the drafts, and the lenders of the money sold the state stock in the state for what it would bring—some lots as low as 80. The work thus done was in detached lots, as the interest of certain parties prompted the expenditure. As soon as the last issue was made by the state the company stopped, and the state assumed the interest on the $3,000,000 issued to it. In 1842 the company assigned, and its affairs fluctuated until 1844, when Mr. Loder was elected president. In 1845 the state surrendered its lien of $3,000,000 upon the road, and authorized the individual stock to be cut down one-half by holders giving up two shares and taking one new one. A new subscription of $3,000,000 was obtained, and the work commenced anew. Much of the old work was useless; and at this day, when the passenger approaches Dunkirk, he sees, stretching out far away to the right, like an immense army of grim warriors, the piles that were driven originally for the road, at great expense, and then abandoned. From the year 1845 the road began to grow. Starting from Piermont, on the North River, 20 miles above the city, it reached Otisville, 62 miles, in October, 1846. The route was altered, and reached Binghamton, 139 miles, in December, 1848, at a cost of $9,802,433, allowing $1,458,000 for half the old stock, after the release of the state lien. In June, 1849, 22 miles more to Owego were opened; in October 36½ miles were added to Elmira; and it finally reached the lake at Dunkirk, May, 1851. This was a single track, and it was found almost impossible to work it; consequently they put a second track under contract on portions of the road. It was now found that the location of the road at Piermont, to be reached by steamboat, would not answer. The company then made an arrangement with the Paterson and Ramapo road to allow the Erie to come into Jersey City. The Erie railroad, being a wide gauge, 6 feet, and the Paterson road 4 feet 8 inches, it became necessary to lay another rail outside the track, to permit the Erie cars to come over those roads, and the Erie cars reached Jersey City in November, 1853. It is remarkable in relation to this road, that it has depended upon the telegraph to such an extent that it could scarcely be operated without it. It gives constant information of the whereabouts of the trains and the condition of the track, so that the superintendent, wherever he may be, keeps up a constant communication with all the stations. The whole engtth of the road is 465 miles; 81 miles double track and sidings. The maximum grade of the road is 60 feet to the mile for 8 miles, and there is one of 57 feet to the mile. The cost of the road was greatly enhanced by the mode of raising money for its construction, by a constant series of loans, for which were issued first mortgage bonds, second mortgage bonds, bonds convertible in stock in 1862, bonds convertible in 1871, income bonds, unsecured bonds, and other debts, for very few of which the face was obtained, many of them being disposed of at a large discount. By these means the debts of the company ran up to $25,260,000, and the capital, $10,000,000, was in February, 1857, by a dividend of 10 per cent. in stock, money alleged to have been earned and sunk in the Long Dock, raised to the sum of $11,000,000. This load of debt exceeded the ability of the company, and it went finally into the hands

of a receiver. The length of the road is 446 miles, and it has a branch of 19 miles from Chester Junction to Newburgh, making 465 miles. It leases of other companies 95 miles, consequently operates 560 miles; and it has 282 miles of second track. There are 219 locomotives, 160 passenger cars, 49 second class cars, 45 baggage cars, and 2,763 freight cars. The company connected with Jersey City over the track of the New Jersey Transportation Company, but it projected an independent connection through what is called the Long Dock. This embraced a tunnel of 2½ miles through Bergen ridge, and 2½ miles of road running out on to docks and piers built out to deep water. The Long Dock Company was chartered by the state of New Jersey with a capital of $800,000. It purchased $773,440 worth of real estate. The Erie Company leased this at 10 per cent. of the capital, and then commenced expenditures on the tunnel, which is 4,880 feet long, and up to January, 1860, it had expended $1,500,000. This, among other causes, brought the Erie railroad to default; and in August, 1859, at the suit of the fourth mortgage bondholders, a receiver was appointed. It was then proposed, as a means of arrangement, to capitalize the unsecured bonds, with the interest for two years, into a preferred 7 per cent. stock; to extend the first mortgage bonds coupon to March 1, 1860; the second mortgage to September, 1860; the third to March, 1861, and the balance to December, 1861. It is estimated that the road will clear the other claims upon it, and complete the Long Dock. The business of this road from 1842 to 1859, inclusive, was as follows:—

RECEIPTS.

Receipts from passengers	$14,428,024
" " freight	29,902,826
" " mails, &c.	1,586,935
Total	$45,917,785

EXPENDITURES.

Operating expenses	$28,993,114
Dividends	3,481,445
Total	$32,474,559

The Camden and Amboy railroad and Delaware and Raritan Canal Co., of New Jersey, is one of the oldest passenger roads, having been chartered in February, 1830, with the canal privilege. The last is 43 miles from Bordentown to New Brunswick; and the former, South Amboy to Camden, New Jersey, 63 miles. There was to be no rival route within five miles of it. In 1831 the company gave the state 1,000 shares of stock, and a new act was passed consolidating the canal and railroad companies; fares not to exceed $3 between New York and Philadelphia. In the following year 1,000 shares more were conveyed to the state. In 1837 the road was permitted to extend to New Brunswick; fares limited to 5 cents per mile. In 1842 the transit duties on the road were fixed at 10 cents per ton for freight, and one-half of all above $3 charged for passengers. The road was opened to Camden in 1834. In 1843 an arrangement was made with the New Jersey Transportation railroad for through passage from New York to Philadelphia. The Camden road cost $5,563,580, and the New Jersey railroad, Jersey City to New Brunswick, 31 miles, $4,719,176. The Camden road has paid in 25 years 281 per cent. dividends, or 11¼ per cent. average.

The New Jersey Central road extends from Elizabethport, 12 miles by water from New York, to Easton, on the Delaware; at Elizabeth it connects, also, with the New Jersey railroad; at Easton it commands the great Pennsylvania coal fields, and, prospectively, it will unite New York city with Lake Erie, over the Pennsylvania and Sunbury and Erie railroads. The cost of the road is $5,617,290; the capital is $2,000,000; and the debt $3,375,00 .

The great Pennsylvania line of improvements, from Philadelphia to Pittsburg, commenced 4th July, 1826, and finished in March, 1830, comprised 82 miles of railroad from Philadelphia to Columbia, and 36 miles of portage road from Hollidaysburg to Johnstown; this consists of a series of inclined planes, which are worked by stationary engines. This 118 miles of railroad was prolonged by 278 miles of canal, and the cost of the whole to the state was over $12,000,000. This broken line was not very well calculated to compete either with the continuous water service of the Erie canal or the uninterrupted passage of freight on the New York railways. The citizens of Philadelphia felt the want of works better adapted to the growing wants of that great city; and a new railroad was proposed from Harrisburg to Pittsburg, 250 miles. The route is favorable, except for the mountain division, where the summit is crossed, 2,200 feet above tide water, requiring gradients 95 feet to the mile. These are but little in excess of those

of the Massachusetts lines, which are worked to advantage. This work was opened through, November 15, 1832, at a cost of $7,978,000. It proved very successful, and up to November, 1855, its profits, over interest on capital, were, in accordance with its charter, credited to construction account, and it has since paid 6 per cent. The state line of public works did not succeed financially, and the state determined to sell it. After repeated offerings it was finally purchased by and transferred to the Pennsylvania railroad in 1857 for $7,500,000, which was met by an issue of the 5 per cent. bonds of the company to the state, payable, $100,000 per annum until 1890, and the balance, $4,300,000, in four equal instalments annually thereafter. When the road took possession of the state works, the canals were found to be in a dilapidated condition, and the railroad needed repairs, which required assessments. The route then became continuous by rail from Philadelphia to Pittsburg, 353 miles. From Philadelphia 8 miles to the Susquehanna river there is a double track, and other portions of the road raise the double track to 242 miles. The cost, including the state line, is $30,168,987, composed of capital, $13,240,225, and $17,571,054 of bonds. A part of the cost is composed of $816,050 advanced to the Pittsburg, Fort Wayne, and Chicago railroad, which prolongs the Pennsylvania road to the latter city. That road was composed of three roads, viz.: the Ohio and Pennsylvania, the Ohio and Indiana, and the Fort Wayne and Chicago roads. These were consolidated into one company in 1856, and the line completed from Pittsburg to Chicago in 1859, 471 miles, at a cost of $16,079,590, of which $5,259,040 is capital, and $7,956,075 bonds. To assist the completion of this road, the Pennsylvania Railroad Company took up the rails on the 36 miles of portage road which it had bought of the state, and which was of no use, as it run parallel to its own road, and gave them to the Pittsburg road to complete its extension from Plymouth into Chicago. For this iron and the expense of taking up and moving, the Pittsburg road gave its first mortgage bonds for $650,000. The business of the Pennsylvania road, connecting, as it does, Philadelphia with Chicago and the whole net-work of railroads between and beyond these cities, is not only profitable to itself, but of immense value to Philadelphia.

We have stated that a portion of the great Baltimore and Ohio railroad was finished two years before the opening of the Manchester road in England. The company received two charters: one from the state of Maryland, February, 1827, and the other from the state of Virginia in the following March, with authority to construct a road from Baltimore to the Ohio river. The capital authorized was $5,000,000, and the company entitled to organize on the payment of $1,000,000. The company was so organized in April of the same year, and with the aid of several officers of the United States topographical corps, the road was partly located in the same summer. July 4th, ground was broken by Charles Carroll, of Carrollton, and the portion of the road to Ellicott's Mills was put under contract. The capital of the company, at the close of 1828, reached $4,000,000, of which three-fourths was taken by individuals, $500,000 by the city of Baltimore, and $500,000 by the state of Maryland. The road was gradually extended to the Point of Rocks in 1832. Here arose an obstacle of right of way. The Chesapeake canal had appropriated the narrow gorge through the mountain, and several years of negotiation elapsed before the difficulty was finally settled by the legislature. In 1833 the Washington branch was chartered, on the condition that at least 25 cents per passenger should be paid to the state. The Baltimore and Ohio Company contributed $1,016,800 toward the construction, and it was opened 30 miles to Washington, August 25, 1835. The road had then no locomotives, horse power being used. The company offered $4,000 for a locomotive of American manufacture to burn coal. One was invented by Phineas Davis and accepted. It ran 15 miles per hour on short curves and 30 miles on a straight line. The rails were flat bars laid on stone foundations, which soon gave way to longitudinal timbers with improved rails. The road reached Harper's Ferry in 1834, and the state subscribed $3,200,000 for the extension to Wheeling. In 1838 the state of Virginia extended the time for construction through its territory and subscribed $1,058,420. The road was then completed to Cumberland in 1842, but nothing further was done until 1847. Virginia again extended the time, and in 1849 state bonds granted to the company furnished means for pushing the road to completion, 1853. The city of Baltimore then furnished $5,000,000, which was expended in protecting tunnels,

double track, etc. There is one tunnel of 4,137 feet, and the length of all the tunnels is 12,804 feet.

A charter for the Parkersburg branch was granted in 1851. The work began December, 1852, and was completed May 1, 1857. The road was built jointly by the city of Baltimore and the Baltimore and Ohio Company. The former gave $1,500,000 first mortgage bonds, and the latter $1,000,000 of its second mortgage bonds, and has since advanced $1,795,326. The road is operated by the Baltimore Company under a contract for five years, at a rent of 40 per cent. of the gross earnings.

The capital of the Baltimore Company is $10,011,800, and the funded debt $13,881,833. There are three sinking funds operating to redeem these debts, and all amount to about $1,200,000. The total earnings of the main road for 30 years were $9,744,351 from passengers, $29,604,970 from freight; total, $39,349,321; the amount, less expenses, was $17,421,250, and the total amount of dividends paid has been $4,589,866. These range from 1 to 7 per cent., and during the five years ending with 1852, were paid in stock.

The traffic of the road east is mostly in coal. Thus, of 566,214 tons delivered at Baltimore in 1859, 323,898 was coal. The number of passengers on the road and branches going west in 1859 was 338,037; going east, 349,501. Tons of freight going west, 303,104; going east, 770,452. This road has exercised an immense influence upon the business of Baltimore, and opened a route to the Ohio valley which rivals the Pennsylvania and the great New York routes.

The Virginia Central railroad, which now connects Richmond 195 miles with Jackson's River, was originally chartered, in 1836, as the Louisa railroad, with a capital of $300,000, and in 1837 the board of public works was authorized to subscribe on behalf of the state $120,000. In December, 1837, twenty-three miles of the road were opened. It was further extended in the following year, and in 1840 the road reached Gordonsville. Under new privileges, granted in 1848, the work was resumed, and reached Charlottesville in May, 1850, but in that year some new privileges being asked, the name of the road was formally changed to the Virginia Central railroad. There were then seventy miles in operation, and extensions at both ends were proceeded with; of these in 1851 twenty-three miles were completed, bringing the road into Richmond. It was not until 1857 that the road was opened through to Jackson's River, 195 miles, at a cost of $5,362,910; of this $3,132,445 is capital paid in, $1,878,493 by the state, and the balance by individuals. The highest grade of the road going west is eighty-three feet per mile for 1½ miles, and going east seventy-two feet per mile for fourteen miles. There are 107 miles straight, and 77 miles curved, of which the smallest radius is 716 feet for ¼ mile. The rails are all T, from fifty to sixty pounds per yard. The cross ties 2,400 to the mile. The business of the past year was as follows:—

Going	Passengers.	Freight. Tons.
East	33,629	66,678
West	30,548	68,205
Total	64,177	134,883
Earnings	$311,980	$306,212

This road from its opening, 1837, to the close of 1859, earned as follows: average length, 90 miles; passenger earnings, $79,583; freight, $89,773; gross earnings, $180,009; expenses, $94,486, dividends paid, $22,971; per cent., 2.

In casting the eye upon a railroad map, the line from Bangor, Maine, to New Orleans, 1,996 miles, is found to be composed of nineteen grand links; one of the largest of these is that which connects Lynchburg, Va., with Bristol, Tenn., 204 miles. This was called the Virginia and Tennessee. It was opened in 1854. By this route the mails of the government are conveyed from Washington to New Orleans in seventy-five hours. This commanding position of the road is not, however, more advantageous than its local business, which is derived from one of the most fertile districts of Virginia, as well as rich in mineral. The road opened what had been one of the most secluded portions of the middle states, and vast resources are there to be developed. The cost of the road is $7,050,519, of which $3,418,599 is capital and $2,833,000 bonded debt. The future of this road is one of the most promising.

The next most important link in this great line is the Orange and Alexandria road, connecting Alexandria and Lynchburg, 170 miles. This road was completed in 1859; by it the distance from New York to central Virginia is shortened sixteen miles, and the route to New Orleans, so to speak, straightened. The cost of the road was capital, $1,899,330; bonds, $2,600,000.

The South Carolina road was one of the

first projected in the country. The city of Charleston early saw the advantage and importance of the work, which was commenced in 1830, and opened in 1833. Its main trunk extends from Charleston to Hamburg, on the Savannah river, opposite Augusta, Georgia, 136 miles. The track was originally a trestle-work, on which was laid a thin flat rail. Some of the swamps and rivers were crossed at an elevation of fifty feet. On this road the first successful American locomotive was run. It was called the "Best Friend," and was built under the supervision of E. L. Miller, of South Carolina. It was introduced by Horatio Allen, and ran in 1830, when there were but eight miles of road out of Charleston. The South Carolina road cost $7,701,338, of which $4,179,475 is capital, and $2,730,463 bonded debt. The road owes most of its business to the transportation of cotton, and it pays ten per cent. regularly. Its stock is above *par*. The project of connecting Charleston with Cincinnati was early entertained, and in 1836 a grant was obtained from South Carolina, North Carolina, Tennessee, and Kentucky, for the purpose of constructing a road through Columbia, Knoxville, and Danville to Covington, opposite Cincinnati. This enterprise was swamped in 1837 by the crisis, when the road was partially constructed to Columbia. That project has now been revived by the completion of the Greenville and Columbia road, and the extension of the Blueridge road into Tennessee, thence *via* Knoxville through Danville and Lexington to Cincinnati. A more circuitous road by way of Nashville and Louisville, over the Nashville and Chattanooga, and Nashville and Louisville railroads, has been opened. Charleston thus drains the whole interior country.

The Georgia railroad system is composed of two great lines: one from Savannah to the Tennessee river, 434 miles, and the other, 255 miles, from Augusta to West Point, whence it it prolonged to Montgomery by the Montgomery and West Point road. The Georgia Central, connecting Savannah with Macon, 191 miles, was opened nearly at the same time as the Georgia road connecting Augusta with Atlanta, 171 miles, viz., in November, 1843, having been commenced in 1836. It was chartered with banking privileges, and has been eminently successful. Its capital stock is $4,010,000, and bonded debt $158,767. This road made a dividend last year of 15 per cent., and its stock is now 15 per cent. premium. The Georgia road cost $5,210,372, of which $4,156,000 is capital, and $476,895 bonded debt. The earnings of this road are 15 per cent.

From Atlanta a road stretches to West Point; it has always paid either seven or eight per cent., besides several extra dividends; and last year divided a bonus of thirty per cent. The state railroad of Georgia, built at extravagant cost, and managed by state officials, paid into the treasury last year out of its net earnings about eight per cent. on its cost.

In Alabama, Louisiana, and Arkansas, their fine rivers, navigable for steamboats, and stretching into every part of the states, have made railroads almost unnecessary. But whenever they are built, and can obtain a freight of cotton, they are sure to pay. This product is not like corn, or wheat, or even flour, worth one, two, or three cents a pound, but eight, ten, or twelve cents, and can therefore afford to pay the cost of transportation.

The most remarkable railroad in the world as to extent, location, mode of construction, and magnitude of resources, is perhaps the Illinois Central road. It may be called the corner-stone of a future empire. In 1837, when the population of the state of Illinois was less than 200,000 souls, and these agriculturists scattered over the great state, they undertook with singular boldness a system of internal improvement by canal and railroad, which would involve an expenditure of at least $15,000,000. Among these was the Central railroad, which was to extend from Cairo, at the junction of the Ohio and Mississippi rivers, longitudinally of the state, to Galena at its northern extremity on the Missisippi river, making a line of 457½ miles, which should be the base of a triangle of which the great river formed the other two sides. This road was to cross the Illinois river at the commencement of navigation, or where it meets the canal coming from Chicago. Other roads were projected to cross the state, intersecting the Central road. The Central road was undertaken, and about $3,500,000 spent upon it, when bankruptcy overtook the state, and the road rapidly deteriorated. The progress of the work on the canal, with the funds borrowed on pledge of the land granted by the federal government, had been of great benefit to the state, and had enabled the federal government to sell most of its lands on the canal and great water-courses, in fact, all within reach of market. There remained,

however, some 15,000,000 acres of the richest land in the heart of the state, for which there was no sale, because it was not accessible to market. Experiencing, however, the great results from the canal grant, which not only laid open great tracts to market, but by local expenditure in construction, brought settlers and money upon the vacant lands, it decided upon a similar grant to the state in aid of the Central railroad. Accordingly, in September, 1850, Congress made a grant of lands to the state of Illinois of every alternate section, six sections in width, on each side of the road and its branches, and if any land so situated should be taken up, then any vacant land elsewhere might be selected in room of it, within fifteen miles of the line of the road. The same law conferred upon the states of Alabama and Mississippi similar grants for the extension of the road from Cairo to Mobile city. In the following February the state of Illinois incorporated the Illinois Central Railroad Company, with a capital of $1,000,000, to be extended to an amount not exceeding the cost of the road. The company on its organization was to pay over to the state treasury $200,000, and receive from the state the entire grant of lands made by the federal government, together with all that remained of the old Central road, right of way, etc. The company was to have fifty miles completed within two years, under forfeit of the $200,000 deposited, and which was to be returned to the company on the completion of the fifty miles within the time. The road was to run from Cairo to the western end of the Illinois canal, and thence branch to Galena on the river, and to Chicago on the lake. The company was to pay to the state annually five per cent. on the gross income of the road. These were the leading items of the grant, and the conditions were all carried out. The location and survey of the route showed the company entitled to 2,595,000 acres of land to be selected by the company. This vast tract of land, amounting to an area larger than the whole state of Connecticut, was all to be selected from good farming lands, not an acre of waste in the whole, but all of the richest prairie soil, of the same character as that in the neighborhood of St. Louis, which for two hundred years had given to fresh settlers annual crops, without in any degree deteriorating apparently. These lands of the company were appropriated, 2,000,000 acres, valued at $18,150,000, as a security for $17,000,000 of construction bonds; 250,000 acres were added to the interest fund to meet any deficiency of means from other sources appropriated to interest on the construction bonds; and 345,000 acres were held in reserve, but were finally the basis of $3,000,000 "free land bonds," issued and redeemed by conversion into company stock. The 2,000,000 acres were placed in the hands of trustees, who alone have power to give title to purchasers, and who are required, whenever the funds accumulate to the amount of a bond, to buy and cancel it. No land can be sold, unless bonds to the same amount are cancelled. It was estimated that the bonds thus issued would build the road, and leave the entire work free of cost to the stockholders. It was found requisite, however, to create 170,000 shares, representing $17,000,000 capital. On this instalments have from time to time been called in. The $200,000 deposited with the state was assessed $20 on 10,000 shares, and the amount has since been increased to $26,000,000, on which 80 per cent. has been called, making $20,800,000. In April, 1852, $4,000,000 of the 7 per cent. construction bonds were issued at par, and the subscribers to this loan had the privilege of subscribing ten shares of stock for each $1,000 bond. The company purchased their iron, 72,000 tons, in 1852, when it was very low, or less than half the price to which it rose soon after, when the railroad fever developed itself. In October, 1852, the whole line was put under contract, in divisions, and 10,000 men were employed at an expense of $3,700,000 per annum, at work along the line, twelve hours per day, stretching a great highway through fertile plains never before opened, conferring value on them, wealth to the farmers, and strength to the state. As the work progressed, it encountered difficulties from cholera, and the demand for labor which the growing railroad mania caused. The road was opened in 1854, and its earnings for its first year, 1855, were $1,532,118. It sold of its lands 528,863 acres for $5,598,577, and the sales have since reached 1,267,627 acres for $16,230,326, leaving on hand 1,327,372 acres. These lands are quite as valuable for farms as those sold.

The Illinois Central railroad is the longest continuous line of road under the control of a single corporation in the United States. It owns 112 locomotives (of which number twenty-five burn coal), seventy first-class pas-

senger cars, twenty-four baggage and express cars, and 2,295 freight cars. It has extensive workshops for the manufacture and repair of machinery at Chicago, Centralia, and Amboy, with one or two smaller establishments at other places. The road is intersected by and makes connections with sixteen distinct lines of railroad. At its northern terminus—Dunleith—on the Mississippi river, the cars make connections with the boats of the Minnesota Packet Company for the upper Mississippi. The company have recently erected a grain elevator at Dunleith, by which grain will be transferred from the boats to the cars at a considerable saving in labor and expense.

At Cairo, the southern terminus of the road, the cars make direct connections (by steamer to Columbus, Ky.) with the Mobile and Ohio railroad for Memphis, Natchez, Vicksburg, New Orleans, and other southern cities. In Chicago the company's facilities for receiving and forwarding freight are unsurpassed. Sleeping cars are run on all its night passenger trains.

The land department is the most interesting branch of the company. It is divided into three bureaus—the cashier's office, the sales room, and the contract room. The whole force employed in it comprises about twenty-five clerks, one of whom is a brother of Charles Dickens, the distinguished novelist. He is on the sunny side of thirty, is a quiet, unassuming gentleman, and, it is said, writes considerable for some of the leading literary publications in this country. But to return to the lands of the Illinois Central railroad. They comprise an area covering 4,055 square miles, nearly as large as the territory of the state of Connecticut, twice as large as Delaware, more than half as large as Massachusetts, about the same size as the electorate of Hesse-Cassel, three-fourths as large as the grand duchy of Baden, and half as large as the grand duchy of Tuscany.

The most marvellous result of this great work was manifest in the report of the United States land commissioner. The lands through which the road ran had been offered on an average of 15 years at $1.25 per acre, without finding a buyer. All those lands were withdrawn while the company made its selections. When that was done, the lands were again brought into market, in June, 1852, and these in the next twelve months sold in Illinois 298,861 acres for cash, at $2.50 per acre, and 2,509,120 for land warrants. The sales were double the quantity sold in all the states in the previous year. The whole interest of the government in Illinois was speedily closed out. For lands which had been valueless to it before the completion of the road, it realized over $9,000,000. This was the effect of transportation upon those lands.

The first land grants of the government, as we have seen in a preceding chapter, were in aid of canals. The grant to the Illinois railroad was followed by others, and the aggregate grants are as follows to each state:—

	Grants for internal improvements.	Railroad grants.
Ohio	1,243,001.77	....
Indiana	1,609,861.61	....
Illinois	500,000.00	2,595,053
Missouri	500,000.00	1,815,435
Alabama	500,000.00	2,332,918
Mississippi	500,000.00	1,687,530
Louisiana	500,000.00	1,162,580
Michigan	1,250,000.00	3,096,000
Arkansas	500,000.00	1,465,297
Florida	500,000.00	1,814,400
Iowa	1,385,078.22	3,456,000
Wisconsin	1,069,371.99	1,622,800
California	500,000.00	....
Minnesota Ter.	340,000.00	4,416,000
	10,397,313.59	25,464,013

The grants for internal improvements include the canal grants to Ohio, Indiana, and Illinois, as well as for river improvements. The railroad grants, it appears, amount to nearly 25,500,000 acres. These grants have been applied to that purpose by the several states, not always, however, with the best success. The state of Wisconsin was unfortunate in the grants of the state rights, and the land has been withheld in some cases. Minnesota founded a railroad system upon her lands, but up to the present time disaster only has attended it. The system was pushed to its extent in 1857, and then suffered a severe revulsion. With the improved demand for farm produce, migration may be expected to be renewed, and the value of the land grants to be restored.

The land grant of the federal government to Alabama for the Mobile and Ohio road was to the extent of 1,120,000 acres, and it became the basis of a sinking fund for the aid granted to the states of Tennessee, Mississippi, and Alabama. The road is to extend from Mobile bay, in a line nearly due north, to the mouth of the Ohio river, opposite Cairo, a distance of 594 miles. Thence by the Illinois Central it will connect with Dun-

leith, on the upper Mississippi, 928 miles, and also with Chicago and the eastern lines. The road was commenced in 1851, and was pushed through Tennessee to West Point in 1857; it is by the law of that state entitled to a guaranteed state credit of $8,000 per mile, which will carry it to the Kentucky line. The work is one of the most important in the whole country.

The Memphis and Charleston railroad connects Memphis, on the Mississippi, with Charleston, by the way of the Nashville and Chattanooga road. This road connects Charleston and Savannah with the leading cities of the Mississippi river. It is 271 miles long, and forms part of the great through line from Washington to New Orleans. It is well built, and pays 12 per cent. dividends. Its cost was $6,351,752, of which $2,258,115 is capital, and $2,594,000 bonded debt.

The New Orleans, Jackson, and Great Northern road forms the southernmost link of the great chain which stretches 2,000 miles on the Atlantic coast to Bangor, thus connecting codfish with sugar, the Maine law with New Orleans rum. The road runs from New Orleans to Canton, Mississippi, 206 miles. It has, as a matter of course, an immense through business as well as a large local traffic. Its cost has been $8,949,183, of which $4,320,618 is capital, and $3,185,000 bonded debt.

There were completed in January, 1860, the last two links in the great chain of railways from Maine to Louisiana—the first, the last twenty-five miles on the Mississippi Central, and the second, of sixty-one miles between Lynchburg and Charlottesville, on the Orange and Alexandria railroad, popularly known as the Lynchburg Extension. This route, as will be seen by the following table of distances, is within a fraction of 2,000 miles in length, from Bangor to New Orleans, of a continuous rail track, with the exception of four short ferries, viz.: the Hudson river, the Susquehanna, the Potomac, and the James river at Lynchburg, the last two of which will soon be supplied with bridges.

From New Orleans to Canton, Miss., by the New Orleans, Jackson, and Great Northern railway	206
Canton to Grand Junction, Miss., by the Mississippi Central railway	165
Grand Junction to Stephenson, Ala., by the Memphis and Charleston railway	219
Stephenson to Chattanooga, Tenn., by the Nashville and Chattanooga railway	38
Chattanooga to Cleveland, Tenn., by the Cleveland and Chattanooga railway	29
Cleveland to Knoxville, Tenn., by the East Tennessee and Georgia railway	83
Knoxville to Bristol, Tenn., by the East Tennessee and Virginia railway	130
Bristol to Lynchburg, Va., by the Virginia and Tennessee railway	204
Lynchburg to Alexandria, by the Orange and Alexandria railway	169
Alexandria to Washington, D. C., by the Washington and Alexandria railway	6
Washington to Baltimore, Md., by the Baltimore and Ohio railway	39
Baltimore to Philadelphia, by the Philadelphia, Wilmington, and Baltimore railroad	98
Philadelphia to New York, by the Philadelphia and New York railroad line	87
New York to New Haven, Conn., by the New York and New Haven railway	74
New Haven to Springfield	62
Springfield to Worcester, by the Western railway	98
Worcester to Boston, by the Boston and Worcester railway	45
Boston to Portland, Me., by the Eastern and Portland, Saco, and Portsmouth railways	107
Portland to Bangor, Me., by the Penobscot and Kennebec, and Androscoggin and Kennebec railways	137
Total	1,996

This vast chain of railways is composed of nineteen independent roads, costing in the aggregate, for 2,394 miles of road, $92,784,084, or nearly one-tenth of the whole railway system of the United States, of which 1,996 miles are used in this continuous line. The roads from Washington city to New Orleans, embracing a distance of 1,249 miles, have had the contract for the great through mail to New Orleans once a day since July 1, 1858.

The state of Michigan, in 1836, contemplated the construction of three railroads to cross the state: the Southern, from Monroe to New Buffalo; the Central, from Detroit to St. Joseph; and the Northern, from Huron to Grand River. For these roads a state debt of $5,000,000 was contracted; and, in 1838, 28 miles of the Central road had been put in operation, which was extended to 146 miles, at a cost of $2,238,289, and the Southern road, 68 miles, at a cost of $1,125,590, when the state failed and repudiated its debt. As a step toward recovery, a bill was passed, at the suggestion of Mr. Charles Butler, of New York, called the "Butler act," by which the state sold the Central road to a Boston company for $2,000,000 of its own bonds, and the Southern road for $5,000,000 to another company.

Little was done, however, until 1849, when Mr. Butler and others reorganized the Southern company, and the road was pushed to completion. As it approached the Indiana line, an old Indiana state charter was purchased, enabling the company to carry their work through that state to the Illinois line, whence, under the general law of that state, it was pushed on to Chicago. The distance from Monroe, on Lake Michigan, to Chicago, is 246 miles, and the work was completed for $5,000,000, or $20,000 per mile in running order, the level nature of the country being very favorable to the construction of railroads. The work was eminently successful, but became involved through its connection with lateral jobs, which covered it with liabilities greater than its business, large as it was, could carry. It was, like the Erie canal, and indeed many other railroads, overlaid with useless and ill-judged expenditure. The company expended $1,312,534 in aid of other roads, many in nowise connected with it, and in keeping up a ruinous competition. The company thus became hopelessly involved in 1857, when its cost had risen to $19,595,407. Its struggles increased its liabilities, while its business declined. Its main line, Monroe to Chicago, is 246 miles, and six branches raise the length to 509 miles, to which 30 miles leased are to be added.

The Michigan Central reached the lake in May, 1849, and was also pushed to completion, going round the foot of Lake Michigan, where the Illinois Central put out a hand to meet it. The connection is thus 284 miles Detroit to Chicago. The cost of this road was $14,548,411. The road was laid with T rail, and was very prosperous. The capital of the company is $6,057,844, and the debt $8,284,063. The road is an important link in the line of connection between Boston and the southern country.

The state of Tennessee has an important system of railroads adapted to every portion of the state. The state guarantees $8,000 per mile for the purchase of iron and equipment, upon the condition that the companies prepare the road bed and defray the charges of construction. The state retains a lien upon the whole property. The roads have been well built.

The state of Missouri had done little toward the construction of roads until the session of 1851, when it agreed to lend its aid to two great lines: the Pacific road, commencing at St. Louis and running across the state, on the south side of the Missouri river, and the Hannibal and St. Joseph road, extending 206 miles across the state from river to river, connecting the two cities named. This last has also a land grant of 600,000 acres, made the basis for $5,000,000 of the company's bonds. The state subsequently enlarged its plan, and agreed to issue some $24,000,000 of its bonds in aid of the railroads. The panic of 1857 supervened before the issue was completed, and many of the roads became embarrassed. The most important of these roads is the Pacific. It has received state aid, direct and contingent, to the extent of $7,500,000, and has also a land grant of 1,127,000 acres. The main line, St. Louis to Kansas city, is 282 miles, running nearly parallel with the Missouri river, and the south-west branch is 283 miles—together, 565. The route open is 63 miles to Syracuse. The cost is $11,701,516, of which $3,319,835 is capital, and bonded debt $8,303,000.

In the following table of the leading railroads of all the states, with the capital paid in and the funded debts outstanding, there are many roads which run through several states. These are given, the whole in those states where their greatest length is. Thus the Boston and Maine road has three miles in Maine, but the whole is put down in Massachusetts. The titles of roads in Italics show the land-grant roads. The figures are from returns a year earlier than those above.

RAILROADS OF THE UNITED STATES—PROJECTED LENGTH AND MILES COMPLETED, WITH THE CAPITAL PAID IN, AND FUNDED DEBT.

Corporate titles of companies.	Total length of Roads.	Length roads completed.	Capital.	Funded Debt.
Androscoggin	36.1	36.1	$151,833	$444,638
Androscoggin and Kennebec	55.6	55.6	457,900	1,748,451
Atlantic and St. Lawrence	149.2	149.2	2,494,900	3,472,900
Branch	1.5	1.5		
Bangor, Oldtown, and Milford	12 3	12.3	135,000	..
Branch	0.5	0.5		
Carried forward	255.2	255.2	3,239,633	5,665,095

Corporate titles of companies.	Total length of roads.	Length roads completed.	Capital.	Funded debt.
Brought forward	255.2	255.2	$3,239,633	$5,665,095
Baring and Lewy's Island	17 2	17.2	226,500	..
Calais and Baring	6.0	6.0	224,113	..
Branch	5.5	5.5		
Great Falls and South Berwick	6.0	6.0	175,000	..
Kennebec and Portland	63.0	63.0	1,287,779	1,280,000
Bath branch	9.5	9.5		
Machiasport	7.5	7.5	100,000	..
Penobscot	33.0	..	180,497	300,000
Penobscot and Kennebec	54.7	54.7	555,228	1,206,800
Portland and Oxford Central	28.5	21.5	430,000	..
Portland, Saco, and Portsmouth	51.3	51.3	1,500,000	..
Somerset and Kennebec	39.0	39.0	169,200	556,900
York and Cumberland	55.0	18.5	370,000	450,000
Total Maine	631.4	554.9	8,457,980	9,458,495
Ammonoosuc Valley	20.8	20.8	371,037	..
Ashuelot	23.1	23.1	246,018	150,000
Boston, Concord, and Montreal	93.0	93.0	1,800,000	1,050,000
Cheshire	53.8	53.8	2,085,925	738,200
Cocheco	37.0	28.5	389,047	420,853
Concord	34.5	34.5	1,500,000	..
Contoocook Valley	14.6	14.6	200,000	..
Eastern	16.8	16.8	492,500	42,795
Great Falls and Conway	46.3	20.5	166,748	209,927
Manchester and Lawrence	26.8	26.8	863,400	33,800
Merrimac and Connecticut Rivers	53.8	53.8	595,587	383,400
Northern New Hampshire	69.2	69.2	3,068,400	299,500
Bristol Branch	12.8	12.3		
Peterboro' and Shirley	10.5	10.5	245,643	..
Portsmouth and Concord	46.8	46.8	250,000	..
Sullivan	24.7	24.7	500,000	750,000
Wilton and Nashua	10.3	10.3	232,227	..
Total New Hampshire	594.8	560.5	13,206,532	4,078,475
Connecticut and Passumpsic Rivers	110.3	90.7	1,200,000	800,000
Grand Trunk of Canada	17.3	17.3	345,000	..
Rutland and Burlington	119.6	119.6	2,233,376	3,145,001
Rutland and Washington	44.8	44.8	950,000	..
Rutland and Whitehall	6.8	6.8	255,706	..
Branch	1.5	1.5		
Vermont and Canada	47.0	47.0	1,350,000	..
Vermont Central	118.0	118.0	5,000,000	3,853,000
Branch	4.0	4.0		
Vermont Valley	23.7	23.7	516,164	793,200
Western Vermont	54.0	54.0	332,000	700,000
Branches	10.5	10.5		
Total Vermont	557.5	537.9	12,182,246	9,291,201
New York and Boston air-line	23.3	..	153,312	..
New York, Providence, and Boston	50.0	50.0	1,508,000	306,500
Providence, Warren, and Bristol	13.6	13.6	287,917	109,937
Total Rhode Island	86.9	63.6	1,949,229	416,437
Danbury and Norwalk	23.9	23.9	279,100	85,000
Hartford, Providence, and Fishkill	197.5	122.4	1,936,739	1,810,500
Housatonic	74.0	74.0	2,000,000	232,000
Naugatuck	57.0	57.0	1,031,800	287,300
New Haven and Hartford	55.5	55.5	2,350,000	964,000
Branches	10.6	10.6		
New Haven, New London, and Stonington	61.5	61.5	960,748	866,000
Carried forward	480.0	404.9	8,558,387	4,244,800

Corporate titles of companies.	Total length of roads.	Length roads completed.	Capital.	Funded Debt.
Brought forward	480.6	404.9	$8,558,387	$4,244,800
New Haven and Northampton	46.4	46.4	922,500	700,000
Branches	8.8	8.8		
New London, Willimantic, and Palmer	66.0	66.0	510,900	1,052,500
New York and New Haven	62.3	62.3	2,980,839	2,219,000
Norwich and Worcester	59.0	59.0	2,122,500	714,998
Allyn's Point Extension	7.0	7.0		
Total Connecticut	729.5	654.4	15,095,126	8,331,298
Belvidere Delaware	64.2	64.2	977,700	2,049,500
Burlington and Mount Holly	7.1	7.1	120,000	..
Camden and Amboy	63.0	63.0	3,798,400	6,882,000
Branch	31.0	31.0		
Camden and Atlantic	60.0	60.2	657,351	1,006,800
Central of New Jersey	63.0	63.0	2,200,000	3,186,000
Extra track	48.0	48.0		
Flemington	11.8	11.8	238,513	..
Freehold and Jamesburg	17.0	11.0	220,666	..
Millstone and New Brunswick	6.6	6.6	111,114	..
Morris and Essex	92.0	53.0	1,157,800	340,000
Newark and Bloomfield	6.0	6.0	101,387	..
New Jersey	33.8	33.8	3,749,000	188,700
Northern New Jersey	21.7	21.7	154,157	..
Paterson and Hudson	14.5	14.5	630,000	..
Paterson and Ramapo	15.0	15.0	248,225	95,000
Sussex	12.0	12.0	357,078	..
Warren	18.7	18.7	1,024,600	600,000
West Jersey	60.0	13.0	216,794	..
Total New Jersey	645.6	553.6	15,982,785	14,348,000
Agricultural branch	28.4	15.1	312,828	..
Amherst and Belchertown	43.0	19.5	295,337	..
Berkshire	21.2	21.2	660,000	..
Boston and Lowell	26.7	26.7	1,830,000	440,000
Branch	1.8	1.8		
Boston and Maine	74.3	74.3	4,076,974	..
Branches	8.8	8.8		
Boston and New York Central	74.5	74.5	3,692,144	..
Boston and Providence	43.5	43.5	3,160,000	174,200
Branches	12.1	12.1		
Boston and Worcester	44.8	44.8	4,500,000	500,000
Branches	24.3	24.3		
Cape Cod branch	46.1	46.1	681,690	190,000
Branch	1.0	1.0		
Connecticut River	50.0	50.0	1,591,100	252,500
Chicopee branch	2.4	2.4		
Danvers	9.2	9.2	203,150	..
Dorchester and Milton	3.3	3.3	136,789	..
Eastern	44.1	44.1	2,853,400	2,030,500
Branches	30.5	30.5		
Easton branch	3.8	3.8	56,353	..
Essex	19.9	19.9	299,107	280,261
Branch	1.4	1.4		
Fairhaven branch	15.1	15.1	396,085	..
Fitchburg	50.9	50.9	3,540,090	100,000
Branches	16.8	16.0		
Fitchburg and Worcester	14.0	14.0	214,296	62,900
Grand Junction	9.0	9.0	1,895,402	..
Hampshire and Hampden	24.9	24.9	298,951	303,014
Hartford and New Haven	5.9	5.9	369,218	..
Horn Pond branch	0.7	0.7	12,000	..
Lexington and West Cambridge	6.6	6.6	250,357	..
Lowell and Lawrence	12.4	12.4	200,000	100,000
Marlboro' branch	3.9	3.9	156,185	..
Carried forward	775.3	737.7	31,621,456	4,433,375

Corporate titles of companies.	Total length of roads.	Length roads completed.	Capital.	Funded debt.
Brought forward	775.3	737.7	$31,621,456	$4,433,375
Medway branch	3.6	3.6	32,554	..
Middleboro' and Taunton	8.1	8.1	149,496	..
Nashua and Lowell	14.4	14.4	600,000	..
New Bedford and Taunton	20.1	20.1	500,000	..
Branch	1.6	1.6		
Newburyport	26.9	26.9	220,240	221,600
New York and Boston air line	32.0	8.6	223,176	675,000
Old Colony and Fall River	79.5	79.5	3,015,100	134,500
Bridgewater branch	7.8	7.8		
Peterboro' and Shirley	14.1	14.1	265,327	..
Pittsfield and North Adams	18.6	18.6	450,000	..
Providence and Worcester	43.4	43.4	1,510,200	300,000
Salem and Lowell	16.9	16.9	243,305	226,900
South Reading branch	8.2	8.2	298,947	..
Branch	0.3	0.3		
South Shore	11.5	11.5	259,685	153,290
Stockbridge and Pittsfield	21.9	21.9	448,700	..
Stony Brook	13.2	13.2	267,364	..
Stoughton branch	4.1	4.7	94,944	..
Taunton branch	11.1	11.1	313,156	..
Branch	0.6	0.6		
Troy and Greenfield	36.5	36.1	385,206	219,000
Vermont and Massachusetts	69.0	69.0	2,214,225	1,003,880
Branch	8.0	8.0		
Waltham and Watertown, horse	2.2	2.2	18,978	..
Western	156.1	156.1	5,150,000	6,125,520
West Stockbridge	2.7	2.7	39,600	..
Worcester and Nashua	45.7	45.7	1,141,000	194,500
Total Massachusetts	1,474.8	1,384.2	49,462,563	13,687,565
Albany and Susquehanna	140.0	..	275,792	..
Albany and West Stockbridge	38.0	38.0	1,000,000	1,289,933
Albany, Vermont, and Canada	31.9	31.9	495,005	1,575,091
Branch	0.8	0.8		
Black River and Utica	108.5	34.9	804,648	700,000
Branch	2.6	2.6		
Blossburg and Corning	14.8	14.8	250,000	220,000
Buffalo, Corning, and New York	142.3	142.0	680,000	2,592,221
Buffalo and New York City	91.0	91.0	755,709	1,720,000
Branch	1.5	1.5		
Buffalo and Pittsburg	75.2	..	133,167	..
Buffalo and State Line	68.3	68.3	1,934,850	1,049,000
Canandaigua and Elmira	69.8	69.8	500,000	..
Canandaigua and Niagara Falls	98.6	98.6	1,300,000	2,195,832
Branch	1.6	1.6		
Cayuga and Susquehanna	34.6	34.6	687,000	411,000
Chemung	17.4	17.4	380,000	70,000
Erie and New York City	63.2	..	352,741	14,000
Genesee Valley	16.0	..	75,689	165,000
Hicksville and Cold Spring	4.1	4.1	52,000	..
Hudson and Boston	17.0	17.0	175,000	..
Hudson River	144.0	144.0	3,758,466	8,842,000
Lake Ontario, Auburn, and New York	73.8	..	71,000	..
Lake Ontario and Hudson River	182.0	..	2,715,186	870,000
Lebanon Springs	22.5	..	324,448	..
Long Island	95.0	95.0	1,852,715	636,997
Hempstead branch	2.5	2.5		
New York and Erie	446.0	446.0	11,000,000	25,326,505
Newburg branch	19.0	19.0		
New York and Harlem	130.8	130.8	5,717,100	5,151,287
Morrisania branch	2.1	2.1		
New York Central	297.7	297.7	24,153,000	14,333,771
Branches, &c	258.2	258.2		
Niagara Falls and Lake Ontario	13.2	13.2	393,721	..
Carried forward	2,724.0	2,057.4	59,837,237	67,112,637

Corporate titles of companies.	Total length of roads.	Length roads completed.	Capital.	Funded debt.
Brought forward	2,724.0	2,057.4	$59,837,237	$67,152,637
Northern, Ogdensburg	118.0	118.0	3,077,900	1,500,000
Branch	3.8	3.8		
Oswego and Syracuse	35.9	35.9	396,340	213,500
Plattsburg and Montreal	20.6	20.6	347,775	..
Potsdam and Watertown	75.4	75.4	665,419	911,000
Branch	2.3	2.3		
Rochester and Genesee Valley	49.7	18.5	557,560	150,000
Rensselaer and Saratoga	25.2	25.2	610,000	140,000
Sackett's Harbor and Ellisburg	18.0	18.0	167,485	278,400
Saratoga and Schenectady	21.0	21.0	300,000	85,000
Saratoga and Whitehall	40.9	40.9	500,000	395,000
Rutland branch	6.6	6.6		
Sodus Point and Southern	35.0	..	35,289	..
Staten Island	26.0	26.0	115,000	..
Syracuse, Binghamton, and New York	80.0	80.0	1,200,130	1,643,126
Troy and Bennington	5.4	5.4	75,370	171,200
Troy and Boston	34.7	34.7	604,911	806,500
Troy and Greenbush	6.0	6.0	275,000	..
Troy and Rutland	17.3	17.3	380,818	..
Troy, Union, and Depot	2.0	2.0	7,611	680,000
Union, Ramapo	0.2	0.2	50,000	..
Union, Syracuse	1.3	1.3	77,414	..
Watertown and Rome	96.8	96.8	1,498,500	685,000
Total New York	3,520.4	2,786.3	70,674,768	74,811,371
Delaware and Maryland	84.0	84.0	361,478	931,500
Newcastle and Frenchtown	16.0	16.0	744,520	..
Newcastle and Wilmington	5.0	5.0	93,000	..
Total Delaware	105.0	105.0	1,198,998	931,500
Annapolis and Elkridge	39.0	39.0	462,000	..
Baltimore and Ohio	379.0	379.0	10,011,800	13,881,833
Branches				
Washington line	30.0	..	1,650,000	..
Hoffman's Mines branch	11.0	11.0	500,000	..
Cumberland and Pennsylvania	22.0	22.0	800,000	..
George's Creek Canal and Iron	21.0	21.0	600,000	..
Northern Central	138.0	138.0	2,260,000	5,578,800
Branches				
Western Maryland	14.0	14.0	300,000	..
Sundry coal railroads, say	40.0	40.0	800,000	..
Total Maryland	694.0	694.0	17,383,800	19,460,633
Alexandria, Loudon, and Hampshire	122.0	41.3	1,403,018	36,188
Manassas Gap	105.0	77.8	2,969,861	775,500
Norfolk and Petersburg	79.0	79.0	1,500,124	590,610
North-western Virginia	103.0	103.0	468,605	5,719,229
Orange and Alexandria	149.0	88.0	1,981,167	2,316,879
Fredericksburg and Gordonville	45.0	45.0	231,573	..
Petersburg and Lynchburg	123.0	123.0	1,365,300	1,851,500
Petersburg and Roanoke	59.0	59.0	883,200	102,500
Richmond and Danville	140.0	140.0	1,980,997	907,491
Richmond, Frederick, and Potomac	75.0	75.0	1,041,880	643,960
Richmond and Petersburg	22.0	22.0	835,750	204,808
Richmond and York River	24.0	24.0	657,812	85,000
Seaboard and Roanoke	80.0	80.0	844,200	472,811
Virginia Central	178.0	178.0	3,132,445	1,485,346
Virginia and Tennessee	204.0	204.0	3,353,672	3,247,500
Winchester and Potomac	32.0	32.0	300,000	120,000
Total Virginia	1,540.0	1,371.1	22,949,604	18,559,316
Atlantic and North Carolina	95.0	95.0	1,545,225	400,000
North Carolina	223.0	223.0	4,000,000	..
Carried forward	318.0	318.0	5,545,225	400,000

Corporate titles of companies.	Total length of roads.	Length roads completed.	Capital.	Funded debt.
Brought forward	318.0	318.0	$5,545,225	$400,000
Raleigh and Gaston	97.0	97.0	973,300	126,200
Roanoke Valley	22.0	22.0	450,073	..
Western, coal	43.0	..	..	..
Wilmington and Manchester	161.0	161.0	1,127,511	1,060,000
Wilmington and Weldon	162.0	162.0	1,340,217	791,055
Total North Carolina	803.0	760.0	9,436,322	2,377,255
Blue Ridge	183.0	13.0	1,916,515	217,577
Charleston and Savannah	102.0	55.0	706,365	195,266
Charlotte and South Carolina	109.0	109.0	1,201,000	384,000
Cheraw and Darlington	40.0	40.0	400,000	200,000
Greenville and Columbia	143.0	143.0	1,429,008	1,145,000
Branches	21.0	21.0		
King's Mountain	23.0	23.0	200,000	..
Laurens	32.0	32.0	400,000	106,218
North-eastern	102.0	102.0	685,743	960,410
South Carolina	136.0	136.0	4,179,475	2,770,463
Branches	106.0	106.0		
Spartanburg and Union	67.0	25.0	1,000,000	..
Total South Carolina	1,064.0	805.0	12,418,106	5,978,934
Atlanta and West Point	87.0	87.0	1,250,000	250,000
Augusta and Savannah	53.0	53.0	733,700	298,500
Barnesville and Thomaston	16.0	16.0	..	..
Brunswick and Florida	67.0	24.0	151,887	..
Central of Georgia	191.0	191.0	3,750,000	106,267
Georgia and Bank	232.0	232.0	4,150,000	373,000
Macon and Western	102.0	102.0	1,438,800	23,000
Main Trunk (Atlantic and Gulf)	4.0	4.0	63,767	..
Milledgeville and Gordon	17.0	17.0	212,500	..
Milledgeville and Eatonton	22.0	22.0	275,000	..
Muscogee	50.0	50.0	669,950	249,000
Rome and Kingston				
Savannah, Albany, and Gulf	68.0	68.0	1,275,901	10,200
South-western	228.0	228.0	2,921,900	396,500
Western and Atlantic	138.0	138.0	5,901,497	..
Total Georgia	1,275.0	1,222.0	22,794,902	1,582,467
Florida	154.0	62.0	2,500,000	..
Florida and Alabama	45.0	32.0	191,485	195,000
Florida, Atlantic, and Gulf Central	60.0	32.0	205,781	204,600
Pensacola and Georgia	253.0	29.0	800,000	..
Tallahassee	22.0	22.0	425,000	..
Total Florida	534.0	177.0	4,122,266	399,600
Alabama and Florida	135.0	65.0	877,953	503,500
Alabama and Mississippi Rivers	88.0	30.0	355,010	109,500
Alabama and Tennessee Rivers	168.0	109.0	1,067,006	777,777
Marion	14.0	14.0	290,000	..
Mobile and Girard	222.0	57.0	1,500,000	..
Mobile and Ohio	518.0	362.0	3,481,791	4,717,497
Montgomery and West Point	116.0	116.0	1,419,769	922,622
North-east and South-west Alabama	209.0	..	650,000	..
Tennessee and Alabama Central	26.0	..	65,184	..
Total Alabama	1,496.0	753.0	9,646,723	7,030,896
Baton Rouge, Gros Tete, and Opelousas	17.0	17.0	225,000	..
Clinton and Port Hudson	22.0	22.0	750,666	..
Mexican Gulf	27.0	27.0	662,911	..
Milnesburg and Lake Pontchartrain	6.0	6.0	212,398	..
Carried forward	72.0	72.0	1,950,975	..

Corporate titles of companies.	Total length of roads.	Length roads completed.	Capital.	Funded Debt.
Brought forward	72.0	72.0	$1,950,975	$
New Orleans and Carrollton	13.0	13.0	497,220	..
New Orleans, Jackson, and Great Northern	258.0	80.0	1,002,959	2,121,000
New Orleans, Opelousas, and Great Western	411.0	206.0	4,437,990	2,817,000
Vicksburg, Shreveport, and Texas	189.0	21.0	882,922	58,744
Total Louisiana	943.0	392.0	8,672,066	4,996,744
Mississippi Central	236.0	236.0	2,000,961	2,554,732
Mississippi and Tennessee	99.0	71.0	798,285	456,949
Southern Mississippi	143.0	83.0	1,000,000	1,400,000
Grand Gulf and Port Gibson	8.0	8.0	200,000	..
Raymond	7.0	7.0	95,000	..
West Feliciana	26.0	26.0	620,000	..
Total Mississippi	519.0	431.0	4,714,246	4,411,681
Cairo and Fulton	78.0	12.0	50,493	327,000
Hannibal and St. Joseph	206.0	206.0	1,770,612	8,768,000
North Missouri	236.0	168.0	2,620,000	3,250,000
Pacific	311.0	182.0	3,330,657	8,203,000
South-western branch	283.0	19.0	66,974	1,400,000
St. Louis and Iron Mountain	8.6	8.6	1,999,300	3,276,000
Total Missouri	1,200.0	673.0	9,838,036	25,224,000
Breckenridge, coal	8.0	8.0	312,000	..
Covington and Lexington	80.0	80.0	1,582,169	2,930,000
Lexington and Big Sandy	133.0	20.0	694,024	sold for 26,000
Lexington and Danville	35.0	13.0	694,444	71,000
Lexington and Frankfort	29.0	29.0	514,409	130,000
Louisville and Frankfort	65.0	65.0	741,069	456,519
Louisville and Nashville, Lebanon branch	269.0	185.0	2,151,430	2,300,000
Maysville and Lexington	90.0	19.0	575,000	..
Paducah and Mobile	26.0	26.0	800,000	..
Portland and Louisville	5.0	5.0	100,000	..
Total Kentucky	740.0	450.0	8,164,545	5,887,519
Central Northern	48.0	48.0	300,000	..
Cleveland and Chattanooga	30.0	30.0	867,210	..
Edgefield and Kentucky	47.0	30.0	333,204	612,000
East Tennessee and Georgia	30.0	30.0	1,289,673	2,020,000
East Tennessee and Virginia	148.0	130.0	536,654	1,902,000
Memphis and Charleston	311.0	300.0	3,809,949	2,659,000
Memphis and Ohio	306.0	300.0	570,000	1,361,000
Memphis, Clarksville, and Louisville	180.0	70.0	298,721	740,000
Mississippi Central, and Tennessee	50.0	60.8	317,447	632,500
Mississippi and Tennessee	100.0	59.0	798,285	554,949
McMinnville and Manchester	41.0	41.0	144,894	406,000
Nashville and Chattanooga	202.0	159.0	2,256,479	1,524,000
Tennessee and Alabama	62.0	46.0	595,922	860,000
Manchester and Alabama	38.0	30.0	216,962	413,000
Total Tennessee	1,543.0	1,346.0	12,335,390	13,684,449
Memphis and Little Rock (Arkansas)	146.0	38.0	351,524	446,000
Sacramento Valley (California)	22.0	22.0	785,950	729,000
Burlington and Missouri	286.0	75.0	752,733	665,000
Chicago, Iowa, and Nebraska	86.0	86.0	516,072	860,000
Dubuque and Pacific	319.0	50.0	838,086	965,000
Iowa Central air-line	438.0	..	245,000	755,000
Keokuk, Fort Desmoines, and Minnesota	140.0	38.0	921,449	570,000
Keokuk, Mount Pleasant, and Muscatine	68.0	11.0	548,216	414,000
Mississippi and Missouri	419.0	107.0	..	..
Total Iowa	1,756.0	367.0	3,821,556	4,229,000

Corporate titles of companies.	Total length of roads.	Length roads completed.	Capital.	Funded Debt.
Ashtabula and New Lisbon	84.8	..	$600,000	..
Bellefontaine and Indiana	118.2	118.2	1,859,813	$1,267,078
Carrollton Branch	11.5	11.5	225,000	..
Central Ohio	137.0	137.0	1,628,356	3,673,000
Cincinnati, Hamilton, and Dayton	60.3	60.3	2,155,800	1,411,000
Cincinnati and Indianapolis Junction	99.1	37.0	1,000,000	..
Cincinnati, Wilmington, and Zanesville	162.8	131.8	2,441,176	3,032,000
Cleveland, Columbus, and Cincinnati	135.4	135.4	4,746,100	38,000
Branches, &c.	5.8	5.8		
Cleveland and Mahoning	75.0	67.0	580,000	1,202,300
Cleveland, Painesville, and Ashtabula	95.4	95.4	3,000,000	1,667,000
Cleveland and Pittsburg	101.0	101.0		
Tuscarawas extension	32.0	32.0		
Hanover branch	1.5	1.5	3,942,368	4,918,325
Beaver extension	22.0	22.0		
Wheeling extension	47.0	47.0		
Cleveland and Toledo, N. div.	109.2	109.2	3,343,812	3,842,720
" " " S. div.	79.4	79.4		
Cleveland, Zanesville, and Cincinnati	114.0	61.4	369,673	575,250
Clinton Line	55.3	..	1,000,000	..
Clinton Line extension	94.6	..	1,983,000	..
Columbus, Piqua, and Indiana	103.0	72.0	750,000	1,600,000
Columbus and Xenia	54.6	54.6	1,490,000	290,700
Dayton and Cincinnati, tunnel	53.2	..	2,000,000	..
Dayton and Michigan	144.0	144.0	2,108,380	2,513,400
Dayton and Western	36.6	36.6	289,692	700,000
Dayton, Xenia, and Belpre	63.0	16.0	437,838	422,658
Eaton and Hamilton	45.0	45.0	469,762	728,853
Four Mile Valley	34.0	..	300,000	..
Fremont and Indiana	120.0	36.0	1,000,000	..
Greenville and Miami	32.0	32.0	300,000	473,000
Iron	47.0	13.0	118,865	50,000
Little Miami	83.4	83.4	2,981,293	1,399,000
Marietta and Cincinnati	173.8	173.8	1,399,000	7,405,917
Hillsboro' branch	21.6	21.6		
Ohio and Mississippi	192.3	192.3	6,584,681	9,880,000
Pittsburg, Columbus, and Cincinnati	117.0	117.0	1,906,736	2,400,000
Cadiz branch	8.0	8.0		
Pittsburg, Maysville, and Cincinnati	225.0	..	390,933	..
Sandusky, Dayton, and Cincinnati	153.9	153.9		
Old line	52.0	52.0	2,697,090	2,134,000
Findlay Branch	16.0	16.0		
Sandusky, Mansfield, and Newark	116.0	116.0	828,583	1,402,572
Huron branch	9.0	9.0		
Scioto and Hocking Valleys	130.0	55.5	403,975	500,000
Springfield and Columbus	43.0	19.5	193,000	150,000
Springfield, Mount Vernon, and Pittsburg	112.0	49.0	1,000,000	1,050,000
Tiffin and Fort Wayne	102.7	..	150,000	..
Toledo, Wabash, and Western	243.0	243.0	3,573,000	7,650,000
Total Ohio	4,282.0	3,060.0	62,326,631	61,376,763
Detroit and Milwaukee	188.0	188.0	2,950,009	4,250,000
Detroit, Monroe, and Toledo	51.0	51.0	1,202,821	..
Grand Rapids and Indiana	183.0	..	..	..
Iron Mountain, N. Michigan	25.0	25.0	600,000	..
Michigan Southern and Northern Indiana	246.0	246.0		
Constantine branch	4.0	4.0		
Old Goshen branch	10.0	10.0		
Michigan City branch	14.0	14.0		
St. Joseph Valley railroad	8.0	8.0		
Jackson branch	42.0	42.0	8,975,400	9,343,000
Goshen air-line	120.0	120.0		
Toledo section	3.0	3.0		
Ohio section of D. M. and T. Railroad	7.0	7.0		
Erie and Kalamazoo	30.0	30.0		
Carried forward	931.0	748.0	13,728,230	13,593,000

Corporate titles of companies.	Total length of roads.	Length roads completed.	Capital.	Funded debt.
Brought forward	931.0	748.0	$13,728,230	$13,593,000
Michigan Central	284.0	284.0	6,057,844	8,284,063
Port Huron and Milwaukee	89.8	..	500,000	..
Flint and Pere Marquette	173.0	..	..	..
Total Michigan	1,477.8	1,032.0	20,286,061	21,877,063
Chicago and Cincinnati	104.0	..	..	..
Cincinnati and Chicago	108.0	108.0	1,196,679	1,006,125
Cincinnati, Peru, and Chicago	102.0	29.0	1,000,000	..
Evansville and Crawfordsville	109.0	109.0	986,061	1,219,100
Evansville, Indianapolis, and Cleveland	155.0	..	835,000	..
Indiana Central	72 4	72.4	611,050	1,166,000
Indiana and Illinois Central	70.0	..	..	..
Indianapolis and Cincinnati	89.8	89.8	1,689,900	1,362,284
Cincinnati extension	20.2	20.2		
Indianapolis, Pittsburg, and Cleveland	84.0	84.0	835,971	1,025,700
Jeffersonville	78.0	78.0	1,014,252	681,000
Knightstown and Shelbyville	27.0	27.0	188,000	..
Lafayette and Indianapolis	64.0	64.0	1,000,000	600,000
Madison and Indianapolis	86.0	86.0	1,647,700	1,336,816
Martinsville branch	26.0	26.0		
Shelbyville branch	23.0	23.0		
New Albany and Salem	288.0	288.0	2,800,000	3,000,000
Peru and Indianapolis	74.0	74.0	1,100,000	820,000
Rushville and Shelbyville	20.0	20.0	120,000	..
Shelbyville Lateral	16.0	16.0	160,000	..
Terre Haute and Richmond	73.0	73.0	1,381,450	230,000
Union Track, Indianapolis	3.5	3.5	265,033	..
Total Indiana	1,692.9	1,290.9	16,831,096	12,447,025
Chicago, Alton, and St. Louis	220.0	220.0	3,500,000	4,500,000
Chicago, Burlington, and Quincy	138.0	138.0	4,631,540	3,158,000
Chicago and Milwaukee	45.0	45.0	988,000	762,865
Chicago and Rock Island	181.8	181.8	5,603,000	1,397,000
Chicago, St. Paul, and Fond du Lac	196.0	196.0	2,000,000	7,369,000
Fox River Valley	33.2	33.2	1,000,000	580,000
Galena and Chicago Union	121.0	121.0	6,026,400	3,783,015
Fulton and Iowa line	105.5	105.5		
Beloit branch	21.0	21.0		
Elgin branch	1.5	1.5		
St. Charles branch	10.5	10.5		
Great Western	178.0	175.6	1,600,000	3,088,426
Illinois Central	308 0	308.0	10,249,210	20,000,000
Chicago branch	250.0	250.0		
Galena branch	146.0	146.0		
Illinois Coal	4.0	4.0	100,000	..
Illinois and Indiana Central	74.5	..	..	..
Illinois River	81.5	..	..	..
Joliet and Chicago	35.0	35.0	750,000	..
Joliet and Northern Indiana	45.0	45.0	1,300,000	..
Mound City	3.0	3.0	60,000	..
Ohio and Mississippi	148.0	148.0	1,780,295	3,292,402
Peoria and Bureau Valley	46.0	46.0	..	600,000
Peoria and Hannibal	129.0	..	200,000	..
Peoria and Oquawka	94.0	94.0	1,560,889	2,200,000
Eastern extension	92.0	92.0		
Quincy and Chicago	100.0	100.0	800,000	1,200,000
Quincy and Eastern	43.0	43.0	..	..
Rock Island Bridge	1.0	1.0	200,000	..
Terre Haute, Alton, and St. Louis	168.5	168.5	3,026,903	5,035,615
St. Louis branch	25.0	25.0		
Belleville division	14.8	14.8		
Tonica and Petersburg	120.0	..	500,000	..
Total Illinois	3,177.4	2,772.4	45,885,237	56,966,324

Corporate titles of companies.	Total length of roads.	Length roads completed.	Capital.	Funded debt.
Alleghany Valley	181.0	45.0	$1,660,000	$400,000
Beaver Meadow	20.0	20.0	1,410,900	2,000
Catawissa, Williamsport, and Erie	63.0	63.0	1,700,000	2,271,536
Cumberland Valley	52.0	52.0	981,900	245,500
Delaware, Lackawanna, and Western	193.0	193.0	3,360,872	6,070,125
East Pennsylvania	36.0	36.0	386,121	365,500
Erie and North-east	22.0	22.0	600,000	400,000
Harrisburg and Lancaster	55.0	55.0	1,087,100	661,000
Hempfield	32.0	32.0	1,809,563	..
Huntingdon and Broad Top	46.0	42.0	425,015	1,000,000
Lackawanna and Bloomsburg	69.0	69.0	710,000	1,000,000
Lehigh Valley	45.0	45.0	1,966,350	1,500,000
Little Schuylkill	46.0	28.0	2,256,100	942,500
Lehigh Coal and Navigation	24.0	20.0	2,479,900	3,619,304
Mine Hill and Schuylkill Haven	145.0	72.0	2,800,000	..
North Pennsylvania	75.0	66 0	3,155,820	2,787,000
Pennsylvania	386.0	386.0	13,249,125	16,932,517
Philadelphia and Baltimore Central	79.0	12.0	..	250,000
Philadelphia, Germantown, and Norristown	24.0	24.0	1,208,500	374,800
Philadelphia and Reading	151.0	151.0	11,737,041	12,195,950
Philadelphia and Trenton	28.0	28.0	1,000,000	..
Philadelphia, Wilmington, and Baltimore	104.0	98.0	5,600,000	2,498,435
Pittsburg and Connellsville	147.0	60.0	1,753,864	1,500,000
Pittsburg, Fort Wayne, and Chicago	467.0	467.0	6,266,278	8,895,457
Pittsburg and Steubenville	31.0	31.0	1,221,277	280,000
Schuylkill and Susquehanna	54.0	54.0	1,258,700	97,000
Schuylkill Valley	39.0	24.0	568,150	..
Shamokin Valley and Pottsville	33.0	28.0	500,000	821,447
Sunbury and Erie	148.0	148.0	4,506,920	4,369,070
Tioga	29.0	29 0	97,550	396,000
Westchester and Philadelphia	26.0	26.0	682,170	944,169
Williamsport and Elmira	78.0	78.0	1,500,000	2,361,973
Total Pennsylvania	2,928.0	2,044.0	57,939,216	73,181,283
Kenosha and Rockford	176.0	55.0	800,000	700,000
Lacrosse and Milwaukee	199.0	199.0	10,872,000	10,414,066
Milwaukee and Chicago	40.0	40.0	1,000,000	600,000
Milwaukee and Horicon	42.0	42.0	1,101,200	..
Milwaukee and Mississippi	260.0	234.0	3,696,693	4,047,000
Milwaukee, Watertown, and Baraboo	130.0	130.0	345,861	132,000
Racine and Mississippi	142.0	136.0	2,705,720	1,417,000
Wisconsin Central	65.0	10.0	600,000	..
Total Wisconsin	1,054.0	846.0	21,121,474	17,310,066
Buffalo Bayou	190.0	32.0	..	..
Galveston, Houston, and Henderson	240.0	56.0	..	..
Houston and Brazoria	125.0	50.0	275,000	240,000
Houston and Texas Central	125.0	70.0	455,000	975,000
San Antonio and Mexican Gulf	135.0	25.0	..	..
Southern Pacific	784.0	28.0	..	..
Total Texas	1,824.0	251.0	730,000	1,215,000
Minnesota and Pacific	620.0	..	..	600,000
Southern Minnesota	175.0	..	..	575,000
Minneapolis and Cedar Rapids	112.0	..	..	600,000
Minnesota Transit	200.0	..	..	500,000
Root River Valley	60.0	..	..	..
Total Minnesota	1,167.0	..	..	2,750,000

There are, in addition to the roads here mentioned, a considerable length, probably 2,000 miles in all, employed in mining districts, and not used for general traffic. The grand result is over 28,000 miles of road, which have cost, in capital and funded debt, $1,066,866,284, which has been expended in the period since the first road was begun.

RECAPITULATION BY STATES.

Corporate titles of companies.	Total length of roads.	Length roads completed.	Capital.	Funded Debt.
Maine	631.4	554.9	$8,457,980	$9,458,495
New Hampshire	594.8	560.5	13,006,532	4,078,475
Vermont	557.5	537.9	12,182,246	9,291,201
Rhode Island	86.9	63.6	1,949,229	416,437
Connecticut	729.5	654.4	15,095,126	8,331,298
Massachusetts	1,474.8	1,384.2	49,462,563	13,687,565
New York	3,520.4	2,786.3	70,674,768	74,811,371
New Jersey	645.6	553.6	15,982,785	14,348,000
Pennsylvania	2,928.0	2,044.0	57,939,216	73,181,283
Delaware	105.0	105.0	1,198,998	931,500
Maryland	694.0	694.0	17,383,800	19,460,633
Virginia	1,540.0	1,371.0	22,249,604	18,559,316
North Carolina	803.0	760.0	9,436,322	2,377,255
South Carolina	1,064.0	805.0	12,418,106	5,978,934
Georgia	1,275.0	1,222.0	22,794,902	1,582,467
Florida	534.0	177.0	4,122,262	399,600
Alabama	1,496.0	753.0	9,646,723	7,030,896
Louisiana	943.0	392.0	8,672,066	4,996,744
Mississippi	519.0	431.0	4,714,246	4,411,681
Missouri	1,200.0	673.0	9,838,036	25,224,000
Kentucky	740.0	450.0	8,164,545	5,887,519
Tennessee	1,543.0	1,356.0	12,335,400	13,684,449
Arkansas	146.0	38.0	351,524	446,000
California	22.0	22.0	785,950	729,000
Iowa	1,756.0	367.0	3,821,556	4,229,000
Wisconsin	1,054.0	846.0	21,121,474	17,310,066
Minnesota	1,167.0	..	..	2,275,000
Texas	1,824.0	251.0	730,000	1,215,000
Illinois	3,177.4	2,772.4	45,885,237	56,966,324
Indiana	1,692.9	1,290.9	16,831,096	12,447,025
Michigan	1,477.8	1,032.0	20,286,061	21,877,063
Ohio	4,282.2	3,060.1	62,326,631	61,376,763
Total	40,224.1	28,007.8	$569,865,924	$497,000,360

The expenditure of such an enormous sum of money, amounting to $54 per head for the average population during the 30 years in which they have been building, is marvellous in so young a country, which, 40 years before this outlay occurred, was mostly destitute of capital. The railroads, however, exist, and capital is now, at this moment, more abundant for general purposes than it was before the construction of the railroads. It is, in fact, cheaper in the general market, and in this we recognize the vast utility of the works in developing capital. The operation has been to bring the production of millions of acres into general circulation, more than supplying the absorption that the railroad building occasioned. It is to be considered that a considerable amount, probably $300,000,000, has been borrowed in Europe. For the, in round numbers, 26,000 miles of road built since 1840, there would have been required very nearly 2,600,000 tons of railroad iron, which, at an average price, was worth $104,000,000. There was imported in the same time, 1840 to 1849 inclusive, 1,714,343 tons, at a cost of $69,799,797, mostly purchased in exchange for bonds. In the six years ending with 1857 there were opened 14,335 miles of railroad, which required 1,304,485 tons. In the same period there were imported 1,289,787 tons. Thus the quantity of domestic required was 14,698 tons in addition to the renewal of old rail. A good deal of iron was bought at very high prices proportioned to the estimated values of the bonds. That some of those bonds have not been paid is true, and also that iron was very bad. The iron has been, therefore, a positive advance to the capital of the country, to be paid out of the products of the earth newly opened to market by its means. In illustration of the value conferred by the means of transportation, we may take the Philadelphia coal fields; these were discovered as fuel in 1820. The quantity that has since been delivered is seen in the following table:—

		Tons.
1820 to 1840	21 years	6,847,179
1840 to 1850	10 "	22,034,961
1850 to 1860	9 "	55,742,000
Total tons coal		84,624,140

This, at an average value of $5, gives $423-120,760. If this coal is assumed to have been transported 100 miles average at the cost of transportation on common roads, the expense would have swallowed up the whole value, but there have been built, running into the anthracite region, the following works:—

	Miles.	Cost.
11 canals	315	$40,556,775
40 railroads	1,564	86,773,269
Total		$127,330,044

Under the supposition that the coal transported pays the interest on this cost, which would be $8,690,000 per annum, then the 7,626,000 tons brought to market last year, at a value of $38,000,000, paid $1.12 per ton, or 22 per cent., thus bestowing a clear value of $29,000,000 per annum upon those fields. The Cumberland coal fields also deliver over the Baltimore and Ohio road 617,010 tons per annum. The annual sale of coal from those regions of Pennsylvania is, including the quantities used locally, $40,000,000. This sum is added to the floating capital of the country as a consequence of the $127,330,044 absorbed in constructing the roads. In other words, the cost of construction is repaid in three years nearly, and a perpetually increasing fund flows down for the promotion of trade, since coal is as much a purchasing power for goods as is gold. What those roads have done for coal have the southern roads done for cotton. Formerly the water-courses were the only means of transportation; and when they were dry or shallow cotton accumulated at the landings until the next flood. The iron arms now stretch out in all directions, and not only is all the cotton grown added to the marketable value, but new lands are brought into action. The effect of railroads upon cotton is seen in the following table, which shows the miles of railroad open in 10 cotton states, and the quantity of cotton produced:—

	Miles of road.	Cotton crop. Bales.		Miles of road.	Cotton crop. Bales.
1841	662	1,634,945	1851	1,560	2,355,257
1842	791	1,683,574	1852	2,010	3,015,029
1843	848	2,378,875	1853	2,515	3,262,882
1844	932	2,030,401	1854	3,040	2,930,027
1845	1,109	2,394,503	1855	3,362	2,847,339
1846	1,169	2,100,537	1856	3,809	3,527,845
1847	1,303	1,778,651	1857	4,165	2,939,519
1848	1,319	2,347,634	1858	4,751	3,113,962
1849	1,415	2,728,596	1859	5,552	3,851,481
1850	1,415	2,096,706	1860	5,914	4,675,770
Total		21,174,422			32,519,111

The value of the 5,914 miles of roads built is not far from $150,000,000, but the value of the cotton produced and brought to market has been in the 20 years $2,900,-000,000. The increase in the value during the last 10 years over the former decade has been $800,000,000. That vast sum has poured out upon the markets of the world as a purchasing power, stimulating industry at home and abroad to produce the equivalents to give in exchange, and which have been consumed by the southern cotton producers.

In the western country the results are still more marked, since a country which was a wilderness has, under the influence of railroads opening the way, become the source of immense wealth. This influence upon the grain business of Chicago is seen in the following table, which shows the number of miles in operation in Illinois and Wisconsin, in each year, and the bushels of grain received in Chicago for corresponding years:—

	Miles of railroad. Illinois.	Wisconsin.	Grain receipts, Bushels.
1841	22	..	40,000
1852	148	20	5,873,141
1853	296	50	6,412,181
1854	1,200	200	12,932,320
1855	1,884	240	16,633,700
1856	2,241	285	21,583,221
1857	2,571	559	18,032,678
1858	2,678	793	20,035,166
1859	2,774	838	21,736,147
1860	2,811	951	40,000,000

The cost of the Illinois and Wisconsin railroads has been $141,283,691, most of it furnished by the eastern states and by Europe. In the same period there have been sold by the federal government, in Illinois, 15,000,000 acres of land, and the canals and railroads have sold 3,000,000 acres. This land now sends forth, it appears, over these

railroads, 40,000,000 bushels of grain, at a value of $60,064,575 per annum, as estimated by Col. Graham, of the United States Engineers, and Chicago sends back, in return, a value of $60,608,779. Two years and a half of such production gives the whole cost of the railroads, and a permanently increasing affluence of wealth from that region. The railroads of the other sections bordering the Lakes have not been less efficient.

As an illustration take Chicago as a great railroad centre:—

	Passengers.	Freight.	Mail and Mis.	Total.
Chicago and Milwaukee	$145,580 84	$46,363 40	$12,235 91	$204,186 15
Racine and Mississippi	41,151 80	114,077 85	..	155,229 05
Lacrosse and Milwaukee	205,745 19	269,941 10	16,767 45	492,458 30
Chicago and St. Paul	102,876 26	194,608 50	12,824 92	390,329 63
Milwaukee and Mississippi	305,305 93	557,900 20	17,479 89	383,176 01
Galena and Chicago	1,022,141 65	472,269 13	53,150 45	1,547,561 33
Mineral Point	14,015 77	37,487 05	1,552 52	53,055 35
Chicago and Iowa	15,379 29	32,817 86	2,555 08	50,853 24
Chicago and Burlington	533,034 75	103,421 97	34,252 92	1,600,709 63
Dubuque	30,900 17	29,468 83	1,200 00	61,578 00
Burlington and Missouri	46,377 58	42,869 46	1,975 06	91,222 10
Chicago and Rock Island	449,526 02	439,152 32	43,101 66	981,789 00
Mississippi and Missouri	90,280 02	124,162 51	3,400 00	717,842 53
Chicago, Altona, and St. Louis	417,800 26	424,734 84	24,753 32	967,288 52
Illinois Central	819,829 87	975,904 87	180,804 28	1,976,578 52
Pitts., Ft. Wayne, and Chicago	742,372 04	699,053 79	126,354 35	1,567,780 18
Michigan Southern	920,366 53	849,528 36	269,452 08	2,039,346 97
Michigan Central	1,013,062 24	931,753 98	71,370 63	2,016,186 85
Total				$15,297,156 85

This gives a value of $15,297,155 earned by roads running into Chicago from almost every point of the compass. A large portion of the earnings were derived from passengers who had been connected with railroad building and land speculation.

While all those rivers, canals, and roads have been busy bringing down produce from swelling numbers of settlers, the traffic of the great outlets has been equally as active. We are to bear in mind that in 1825, when the Erie canal opened, there was no transportation of produce from west to east of the mountains. Bearing that in mind, we shall inspect the following table with interest. It shows the tonnage and revenues of the five great outlets, for the year 1859, as follows:—

THROUGH TONNAGE.

Going	East.	West.	Total tonnage.
New York canals	2,121,672	317,459	3,781,684
New York Central	234,241	113,833	834,379
New York and Erie	200,000	60,000	869,072
Pennsylvania railroad	129,767	103,839	1,170,240
Baltimore and Ohio railroad	135,127	66,470	897,496
Total	3,820,807	667,601	7,552,871

RECEIPTS.

	Freight.	Passengers.	Total receipts.
New York canals (tolls)	$1,723,945	..	..
New York Central	3,357,148	$2,566,369	$6,200,848
New York and Erie	3,108,248	1,154,083	4,394,527
Pennsylvania railroad	3,419,494	1,412,603	5,362,355
Baltimore and Ohio	2,928,411	690,207	3,613,618
Total	$14,517,246	$5,823,262	$19,571,348

Thus these five routes collected in 1859 $14,517,246 in tolls and freights, and $5,823,262 from passenger traffic. This has been the sum of the progress in transportation across the mountains east and west. The vast lines of railroads now in operation are probably more than the present wants of all parts of the country may require, but the glance we have made at the past shows that the country will very soon outgrow this supply of rails, and call for a completion of those projected.

This immense length of continued rail now enables an individual to travel from one extremity of the Union to the other without fatigue; not only are the distances shortened, but every appliance for comfort makes the journey, even to invalids, commodious. For this purpose there have been recently introduced on the long lines, sleeping-cars, wherein the passenger takes his natural rest while the iron horse is whirling him toward his destination at the rate of 30 miles an hour. This is an improvement upon the invention introduced by Captain Bunker, as we have seen on the Hudson river sloops in the early part of the century, whereby gentlemen and ladies could be accommodated with beds. They were probably more necessary in that day, however, when it might have been necessary to while away the time in their berths. The rail cars do not go the less rapidly that the passengers are well accommodated. There have been

many instances not only of berths provided but of births taking place in the cars. Such an event happened on the Long Island cars, which were going at the speed of 40 miles per hour, and a grave difficulty sprang up as to where the young gentleman was born, a problem not easily solved, when towns passed at the rate of a mile in 90 seconds.

We have seen that the passenger of the present day does not occupy much time in performing long distances, and that these passages are by no means costly as compared with the inconvenient mode of locomotion in the olden time. Twenty years since it was recorded as a marvel that a gentleman made the distance from Chicago to Albany in 154 hours, or 6 days and 10 hours, and 24 days from New Orleans to Baltimore was recorded as matter of wonder. Now, 89 hours from New York to New Orleans is an easy passage, and Cincinnati is reached in 36 hours. A passenger is booked through from Bangor to New Orleans in less time than was employed to go from Boston to New York. From New York, as the great centre, lines radiate in all directions, bringing the most distant cities within a more convenient distance than was Philadelphia in the past century.

It is instructive to look back at the changes the means of locomotion have wrought in the views of passengers. At the close of the last century enterprising contractors advertised as follows:—

"PHILADELPHIA STAGE-WAGGON and NEW YORK STAGE-BOAT, *performs* their *Stages* twice a *Week*. John Butler, with his waggon, sets out on Mondays from his House, at the Sign of the Death of the Fox, in Strawberry-ally, and drives the same day to Trenton Ferry, when Francis Holman meets him, and proceeds on Tuesday to Brunswick, and the passengers and goods being shifted into the waggon of Isaac Fitzrandolph's the same day, where Ruben Fitzrandolph, with a boat well suited, will receive them, and take them to New York that night. John Butler returning to Philadelphia on Tuesday with the passengers and goods delivered to him by Francis Holman, will again set out for Trenton Ferry on Thursday, and Francis Holman, &c., will carry his passengers and goods, with the same expedition as above to New York."

By this remarkably ingenious plan and diction of John Butler, everybody got to his journey's end in the course of time; "with the same expedition as above," that is, it appears, from Monday morning to Tuesday night, if Ruben Fitzrandolph's boat did not get aground or becalmed, or weather-bound, or driven off, in either of which cases the time of arrival was dubious. But honest John "with his waggon," was soon "cut out." Those "Yankees," immortalized by Knickerbocker, came down from the north and innovated even upon so admirable an arrangement as was here devised in the tap-room of the "Death of the Fox," Strawberry-ally, under the administration of Jefferson. Ruben's boat with its vicissitudes was abandoned, notwithstanding the attractions of the "Kill van Kull" passage, and a land route through adopted. The attractions of this route were set forth as follows:—

"FOR PHILADELPHIA AND BALTIMORE—SWIFTSURE MAIL STAGE.—A new line has removed from No 2 Courtlandt street to No. 116 Broadway, and is now running between New York and Philadelphia, through a beautiful country, and on the short and pleasant road through Newark, Springfield, Scotch Plains, Bound Brook, Somerset, Arnwell, Coryell's Ferry, Cross Road, Crooket Billet, and Jenkintown to Philadelphia.

"To start from New York every day at 10 o'clock, A. M. (Sundays excepted,) lodge at Somerset, and arrive at Philadelphia next day afternoon. The Swiftsure is the only opposition stage from this city to Philadelphia and Baltimore."

There does not appear to have been much time saved by this new plan, any further than that the vicissitudes of the boats were exchanged for those of muddy roads. Spring coaches had, however, supplanted honest John Butler's wagon, since travellers had become more dainty. A few years more brought steam into competition for the use of travellers, and the number multiplied to such an extent, that, on the occasion of the great semi-centennial jubilee anniversary of the National Independence, held July 4, 1825, it was recorded in *The Philadelphia Gazette*, that 300 New Yorkers were said to have been in Philadelphia. There were passengers enough to fill 35 *coaches!*. Great doings, that, in the travelling way! What would Francis Holman have done with the crowd between Brunswick and Trenton? Travelling had clearly outgrown his arrangements. Well, 35 years more passed on, and railroad connections being constructed, the

papers of the day contained a new advertisement of a trip to Philadelphia. It was no longer "John Butler with his waggon," but that "John Brougham with his company" would perform as usual in the evening at the New York theatre, then proceed by the cars to Philadelphia and perform at the theatre there in the same evening, and return to New York to sleep. Thus two performances were had in two cities 90 miles distant, and the passage made both ways in the same evening by rail! The ordinary passage is some 4 hours, and the expense $3.00. The fare is reduced to $2.25, if the passenger does not care about an hour or so of time.

The influence of these great improvements in travel has been in an eminent degree to consolidate population in cities, and these grow the more readily that the distance within which perishable food can be brought to market is so much increased by rapidity of travel. The elements of growth of a city are supplies of food, fuel, and water. Unless these are abundant and cheap, the disadvantages thence arising will counterbalance the geographical and commercial advantages of a city. To supply food the circle of country about the city which supplies market-gardens, dairies, etc., must be fertile and accessible. The width of this ring, or, in other words, the area thus devoted, is determined by the speed with which the produce can be transported. The distance of its extreme limits must not be greater than will permit the products to reach the centre in time for use; any improvement that enables a larger space to be gone over in the same time increases the area of dwellings and market-lands. The area thus commanded increases as the square of the distances. Thus, if the speed is doubled, the area is four times as large, if it is tripled, the area adapted to city supplies is *nine* times as great, consequently there will be nine times as much milk, butter, vegetables, food, and produce as before. Steamboats opened a market in New York for large quantities of early southern fruits and vegetables that compete with those coming by rail from a country before secluded. If the city is thus benefited, so are the distant farms, the value of which, as compared with those near, becomes equalized. If wheat is worth $1.00 in the city, and it cost 25 cents to get it there from a certain farming district, the producer will get 75 cents only. If the cost of transportation be reduced to 10 cents, then there is 15 cents to be divided between the city consumer and the producer. The comparative influence of a railroad in effecting this result over a common road is great.

Another very important development of railroads has been for city service. It is now nearly 30 years since, the city of New York having spread over a greater surface of ground than it was convenient to walk over, lines of omnibuses were started to run on the great thoroughfares, to carry passengers. The price was, at first, 12½ cents for a ride any distance on the line. This was gradually reduced to 6 cents. About the year 1852, however, the plan of horse railroads was proposed, and one was laid down the Sixth Avenue, to the lower part of the city. This was at once eminently successful. The advantages accruing to the general benefit from the development of this system may be briefly enumerated as follows:—The quickest, cheapest, and most agreeable facilities of travel to all parts of the city; the surprising increase of the value of property upon the outskirts, now easy of access at all hours of the day and evening; the spreading of the laboring population to the suburbs, and the consequent rapid extension of the city; the opening of new branches of occupation by the necessity created for conductors and drivers, and the building of cars; and, lastly, the creation of an extensive and profitable investment for capital, the stock of some of these lines of railway being eagerly sought as safe and lucrative. It resulted, that others were put into operation. The plan was soon adopted in Boston, and in Philadelphia, which is, from its broad and rectangular streets, well adapted to railroad travel. From there the system has spread to Baltimore, Pittsburg, Cincinnati, St. Louis, New Orleans, and other cities. The extent of the roads is as follows:—

	No.	Miles.	Cost.
Boston	5	30.4	$968,943
New York and Brooklyn	7	56.8	5,212,586
Philadelphia	18	154 8	8,550,000
Total	30	242.0	14,731,529

The amount of traffic on these roads is immense. In New York, the number of passengers carried in a year more than equals the whole population of the United States. Thus while the railroads favor the settlement of cities, by concentrating in them a large manufacturing and commercial population, which can draw cheap food from

every section of the Union, they at the same time circulate that city population cheaply and speedily, enabling them to occupy a larger space of ground, and at the same time concentrate the manufacturing operations in a manner to facilitate the greatest production of commodities that are reciprocally required by the producers of food. In no country have railroads been availed of to the extent which the United States exhibit. Under the free action of the national energy, the roads have multiplied in a marvellous manner, but it is to be remembered that this has had an immense tract of rare and fertile soil to respond to the operations of the roads, and the country has been taken up, step by step, by an immense immigration. Such a state of affairs cannot exist in Europe. There are no new lands and crowds of immigrants, the resources of which need only the railroad to be developed. There the money put into railroads is a positive investment, here it calls into activity a sum larger than its own amount. The gross income of 257 roads in the United States, for 1859, was $111,203,245 freights and passengers, or $4 per head for each soul in the Union. This was for goods transported and for travelling. The roads of the United States, as compared with Europe and Great Britain, will be seen in the following tables of the number of miles in operation throughout the globe at the commencement of the year 1857:—

United States	28,500 miles.
Canada and British Provinces	1,465 "
Cuba	391 "
Jamaica	10 "
New Granada	49 "
Brazil	53 "
Peru	22 "
Chili	80 "
England and Wales	6,426 "
Scotland	1,138 "
Ireland	1,012 "
Spain	263 "
France	3,712 "
Belgium	1,119 "
Holland	422 "
Denmark	188 "
Norway and Sweden	67 "
Russia and Poland	637 "
Prussia	2,309 "
Smaller German States	4,235 "
Austria and Hungary	1,697 "
Switzerland	167 "
Italy	812 "
Egypt	132 "
British India	311 "
Australia	39 "
Total of railways in the world in 1857	55,256 "

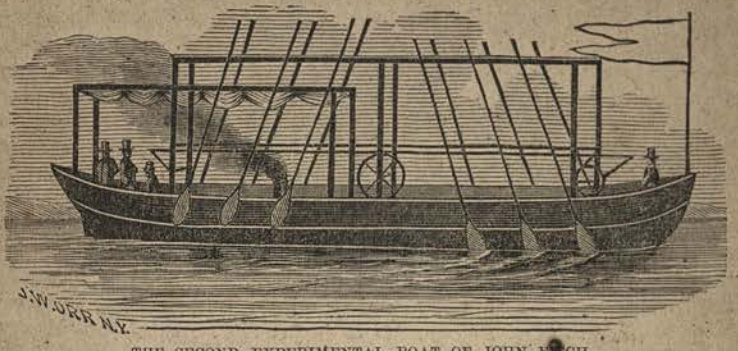
The comparative cost of the roads by another authority is as follows:—

	Miles.	Cost.	Cost per mile.
United States	28,037	$1,086,865,399	$38,800
Great Britain	8,297	1,487,916,420	179,000
France	4,038	616,118,995	152,000
Germany	3,213	228,000,000	71,000
Prussia	1,290	145,000,000	63,000
Belgium	1,095	98,500,000	90,000
British Provinces	826	41,600,000	50,000
Cuba	359	16,100,000	41,000
Panama	47	7,000,000	150,000
South America	60	4,500,000	75,000
Russia	422	42,000,000	100,000
Sweden	75	7,500,000	100,000
Italy	170	17,000,000	100,000
Spain	60	6,000,000	100,000
Africa	25	3,100,000	125,000
India	100	15,000,000	150,000
Total	48,114	$3,823,200,814	$79,000

Although the territories of the United States abutting on the Pacific coast and the north-west were the scene of Mr. Astor's enterprise early in the century, California, up to the Mexican war in 1846, was an unknown region. That war resulted in an acquisition of territory, that was no sooner annexed, than the inquisitive settlers discovered those gold treasures that set the world in a blaze, and made that region the centre of migration for many years. The route thither was by Cape Horn, on a voyage of many months, or across Central America, by a perilous journey. That was not to be suffered long by a people who had learned the art of railroad building, and the Panama railroad, 48 miles, was constructed at a cost of $8,000,000; $4,973,000 capital, and $2,427,000 debt. This road, connecting on the Atlantic side with New York by a steam-line, and on the Pacific side with San Francisco, by another, became at once the great route, and its revenue last year was $1,925,444. The facilities of trade thus afforded, caused a rapid multiplication of people in the north-west coast, the more so that new discoveries of gold were being made. Meantime the public mind was awakened to the necessity of an inland route by rail, not only to shorten the transport trade from India, but as a means of support, in case of war, and also as a bond of union. The undertaking was regarded with hesitation, even by those who had seen the active progress of great works among us. It was supposed impossible to build a road 2,000 miles to connect St. Louis with San Francisco, across the mountains, although the map shows a line be-

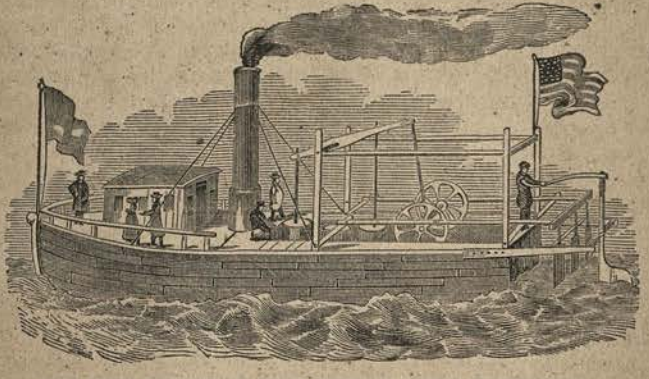
tween St. Louis and New York, and between New Orleans and Brazos. What is there more difficult in one than in the other? It is said the country is unsettled! What was the country between Detroit and New Orleans, through which there are now 1500 miles of road, 25 years since? The settlement of the country goes on at a railroad pace. The frontier line of the country is 1600 miles. Along this the population advance west, at the rate of 1,000,000 souls per annum. The demand for a railroad in 1850 came from 20,000,000 people, without any answering reply from beyond the Rocky Mountains. The demand is now prolonged by 30,000,000 to whom 500,000 voices from the Pacific coast respond. Before the roads can be constructed, if now undertaken, 40,000,000 on the east of the mountains will be eager to communicate with 1,000,000 on the western slopes. These vast numbers will be pressing toward each other, so as to shorten the purely through route, increase the local traffic at both termini, and a terminus which shall be 500 miles south of one centre and 500 miles north of another, will not suffice. The mind at once becomes impressed with the necessity of having *three*. Let us revert thirty years, to the connection of the Atlantic with the Mississippi river. Suppose the necessity of a railroad connection had then been agitated to run 12 or 15 hundred miles to St. Louis; that one connection would have ill supplied the numerous routes that now cross the country between Canada and Charleston. A parallel case will soon present itself with the western slopes, and three routes will be found by no means too many, either to answer the purposes of communication or to accommodate the travel. The requisites of a road are *shortness* and *cheapness*. These are relative. The road which is shortest and cheapest to connect the Columbia river with the great northern interests, including those of Canada, which concentrate round Lake Superior, is not the shortest and cheapest mode of reaching New Orleans from San Diego; nor would a route between the two latter at all accommodate those northern interests. The Pacific railroad extended from St. Louis to San Francisco would be the shortest and cheapest for those central interests, but it could not advantageously do the business of the other sections.

Each of these sections has large means that can be applied to the construction of a road that would serve their necessities, but which could not be enlisted in favor of one that would be of no direct benefit. If, therefore, the government should give authority for the construction of three roads, with a grant of six-mile sections along the route of each, and in addition aid each by a grant of $50,000,000 of 5 per cent. bonds, taking a first lien upon the road, the local interests of each section would complete the balance. Migration will follow these lines of communication settling the best lands, until those coming east will meet those proceeding west, and a continuous line of settlement will follow the rising sun from New York to San Francisco, and the entire Union be united with the waters of the Pacific, that bring the commerce of Asia on the east, and with those of the Atlantic, that float its commerce with Europe on the west.



THE SECOND EXPERIMENTAL BOAT OF JOHN FITCH.

Finished in May, 1787, and run at the rate of four miles per hour on the Delaware. Cylinder twelve inches in diameter, stroke three feet.



THE FIRST STEAMBOAT EVER BUILT TO CARRY PASSENGERS.

Constructed by John Fitch, and finished April 16th, 1798. Cylinder eighteen inches in diameter, speed eight miles per hour in smooth water. The following year this boat was run to Burlington regularly as a passenger boat.

STEAM.

BY JOHN C. MERRIAM.

CHAPTER I.

INTRODUCTORY.

HISTORY OF STEAM ENGINE.

One hundred years ago, a harmless vapor arose with the morning sun, and floated o'er our heads, remarked by the artist, poet, or philosopher, but almost unheeded by the mechanic, and only regarded by the mariner as a prognosticator of the wind.

How is it to-day? From myriad towering columns, o'er which the fierce fire-king his sombre mantle flings, gushes, in mimic clouds, the quick breath of our new-born Titan. The ancient rocks echo to his shrill voice, and tremble as he rushes by. He troubles the waters, and rides on their crest defiant. O'er hill and dale, and lake and river, is his white flag unfurled, proclaiming peace to all nations. From the pine of the frozen north, to the palmetto of the sunny south, his twin track tunnels the mountain, belts the prairie, and spans the flood. Mightiest of kings is this son of fire! proudest of monarchs is this genius of the lamp and the fountain!

In an article like this, it is not necessary that we should dwell upon the genius of James Watt — abler pens have awarded him the fame he so richly deserves, and a proud monument in Westminster Abbey tells the passing stranger that it was

NOT TO PERPETUATE A NAME,
WHICH MUST ENDURE WHILE THE PEACEFUL ARTS FLOURISH;
BUT TO SHOW
THAT MANKIND HAVE LEARNED TO HONOR THOSE
WHO BEST DESERVE THEIR GRATITUDE,
THAT THE KING,
HIS MINISTERS, AND MANY OF THE NOBLES
AND COMMONERS OF THE REALM
RAISED THIS MONUMENT TO
JAMES WATT,
WHO, DIRECTING THE FORCE OF AN ORIGINAL GENIUS,
EARLY EXERCISED IN PHILOSOPHIC RESEARCH,
TO THE IMPROVEMENT OF
THE STEAM-ENGINE,
ENLARGED THE RESOURCES OF HIS COUNTRY,
INCREASED THE POWER OF MAN,
AND ROSE TO AN EMINENT PLACE
AMONG THE MOST ILLUSTRIOUS FOLLOWERS OF SCIENCE,
AND THE REAL BENEFACTORS OF THE WORLD.

What greater praise could be awarded to him than this? How could his unrivalled genius be more concisely expressed, or clearly acknowledged? and yet, at that time, they had but begun to see the stupendous results of his inventions. To realize the inventive mind of James Watt, it requires careful study, and thorough mechanical knowledge, even at this late day; and when we consider that with him all was comparatively novel, we pause in astonishment at a mind so fertile in mechanical devices.

England, ever true and grateful to her *own* genius, has fitly honored her greatest inventor, while America has suffered genius as great to die, unrewarded in life, and forgotten in the grave; but she has not neglected to profit by their inventions; and it is our purpose to show, in this article, how great have been the results.

The first steam engine of which we have any knowledge in America was at the Schuyler copper mine, Passaic, N. J. It was, more properly speaking, an atmospheric engine, and was imported from England in 1736, and put up by a Mr. Hornblower. The first engine that was constructed in America was built by Christopher Colles for a distillery in Philadelphia; the machine was, however, very defective. It was built in October, 1772, and was, like the other, an engine upon Newcomen's plan.

Thus it will be seen that it is less than a hundred years since America took her first lessons in a science that was destined to work such a revolution in the whole world; and her birth, as a nation, may be considered as cotemporary with that of the steam engine. In 1787, John Fitch, of Connecticut, built, in Philadelphia, the first condensing engine, and this without the aid of Watt's experiments—for it was only in the year 1786 that the latter patented, and made public, his most important improvements; and we have every reason to believe that Fitch was at first ignorant of them. With

the assistance of common blacksmiths, he constructed a low-pressure engine, and, more than this, applied the motor to a steamboat. Then came the experiments and success of Robert Fulton, a man whom we have not forgotten to honor; the improvements of Stevens, to whom we owe our great success in river navigation, and the energy and perseverance of Oliver Evans, the first to apply the principles of the high-pressure, or non-condensing engine, to common use, and to demonstrate its advantages not only for the stationary engine, but also its adaptability to carriages on common roads; from which we may date the invention of the locomotive engine, for it was only the experience of Stephenson in tram-roads that led him, at a much later day, to the invention of the latter, and Watt's engines would never have become applicable thereto, on account of their great size.

In spite of the difficulties under which a young nation labored, from the want of an accumulated capital, we took a start from the first introduction of the locomotive engine, that has astonished the world; and have grown a race of civil engineers that, with a limited amount of money, have produced effects wonderful even to themselves. Well may Americans be proud of the results of their inventive genius. To the general reader these events have come to be a matter of course, and steam, with its thousands of detailed improvements, is looked upon as something wonderful, but inexplicable; the mass of people understanding little or nothing of its nature. We propose, then, to explain, as simply as possible, the cause of this great effect, and, dropping technicalities, to give the great public a concise idea of steam, and the steam engine, before proceeding to the results of its use.

When Watt constructed his first engines, he used them to replace horses in the mines, and, in order to give some idea of their value, he reckoned his engines as at so many horses' power; and the power of a horse was computed from the effect produced by a horse raising a weight to a certain height in a given time: this he computed as 33,000 lbs., raised, in one minute, to the height of one foot. The following description, from S. Holland, chief engineer of the English navy, concisely shows the manner of obtaining the horse-power of a steam engine:—

"Work is a term in mechanics of recent origin, but of great utility; it means a compound of force (or pressure) and motion. Work is said to be performed when a pressure is exerted upon a body, and the body is thereby moved through space. The unit of a pressure is one pound, the unit of space one foot, and work is measured by a 'foot-pound' as a unit. Thus, if a pressure of so many pounds be exerted through a space of so many feet, the number of pounds is multiplied into the number of feet, and the product is the number of foot-pounds of work; hence, if the stroke of a steam engine be seven feet, and the pressure on each square inch of the piston be 22 pounds, the work done at each single stroke, for each square inch of the piston, will be 7 multiplied by 22, equal to 154 foot-pounds. Power contains another element in addition to those contained in work. It implies the ability to do so much work *in a certain period of time*; and, in order to have a proper idea of it, a unit of measure is also employed. This unit is called a 'horse-power,' and is equal to 33,000 pounds raised through a space of one foot in one minute; it is the execution of 33,000 foot-pounds of work in one minute. To find the horse-power of a steam engine is to find the number of pounds pressure on the piston in square inches, and to multiply this by the number of feet travelled by the piston per minute, which gives the work; then this is divided by 33,000 pounds, and the quotient is the horse-power, which is usually abbreviated H. P. As the pressure is always indicated by the square inch, the number of square inches in the area of the piston has to be found. This is done by squaring the diameter of the piston, and multiplying this by the decimal, '7854."

The horse-power of an engine is always calculated with the steam in the boiler at a moderate pressure, and, consequently, if the steam is kept at a higher pressure, it will be capable of more work, and the engine will be of a greater effectual horse-power than the one given. Hence the terms *real* and *nominal* horse-power. The term horse-power is, in reality, of itself nominal, as Watt, in order to have his engines give satisfaction, added some twenty-five per cent. to the real work of the best horses in Cornwall. Having thus given an explanation of this term concisely, that it may be remembered, we will endeavor to instruct the general reader as to some other terms not always understood, although constantly made use of in conversation.

Engines are divided into two kinds: low and high-pressure, or condensing and non-condensing. The low-pressure engine was, in the main, invented by James Watt; and its peculiarity consists in the fact that, while the steam is entering upon one side of the piston, the steam upon the other side is condensed, and forms a vacuum that adds to the power of the engine from twelve to fourteen pounds to the square inch. Thus, with steam at the pressure of twenty-five pounds only, we have an effective force of nearly forty. The low-pressure engine has the advantage of not carrying so much steam, and, consequently, is less dangerous. From the fact, however, that it is much more complicated and expensive, it is not often used on land, unless for large engines, and its size prevents its adaptation to locomotion.

The high-pressure engine was invented by Leopold and Trevithick, subsequent to the other. Oliver Evans, of Philadelphia, was the first to advocate its use, and, in fact, to practically apply it. Engines of this description discharge the steam, after using it, into the air, and have, consequently, the resistance of the atmosphere to contend with; they are, however, much cheaper, and with properly built boilers are not necessarily more dangerous. All our locomotives are upon this principle, and the draft of the furnaces is accelerated by the rush of the waste or exhaust steam, as it passes into the chimney. The pressure of steam used in our high-pressure engines, averages more than in any other country; from eighty to one hundred pounds per square inch being the common average. In order to prevent an amount of steam from accumulating to a higher pressure than this, the safety valve is placed upon the boiler, so constructed that, when the pressure rises above the point desired, it will open the valve, and allow the surplus to escape. Over-weighting this valve, or not taking proper care of it, and allowing it to rust into its seat, are fruitful sources of boiler explosions. No engineer should run an engine without trying his valve at least once a day.

It is important that the water in the boiler should always be at about the same height; not full, as in that case water is apt to pass over into the cylinders, and the engine is said to be flooded; nor too low, for the heat of the furnace would melt the flues, if they were not covered with water. Various automatic contrivances have been invented to keep the water at the true level; but their liability to get out of order has prevented their use, and engineers unite in the opinion that man's judgment alone is comparative security. To assist the competent engineer, there are several devices. The most common are the three gauge-cocks, placed, the one above the other, at some three inches apart—the centre one being the desired level; by trying these cocks, the exact height can be readily seen. Other water gauges have been in use, some of them since the earliest engines were constructed, upon the principle that a float upon the water will indicate, by means of a rod, its exact height. A glass tube, connected above and below the water line, is much used in our steamers.

In order to determine the steam pressure at any point below that at which it raises the safety valve, various steam gauges have been in use from time to time; the most common in steamboats is called the syphon gauge, and works upon the principle of balancing a column of mercury in a syphon tube. Within the last ten years the spring gauge has come into general use in locomotive and other engines; they occupy but little room, and, if occasionally tested, answer every purpose of the more cumbersome syphon. With the exception of the Bourdon (French) and Schaeffer (Prussian), all the spring gauges in use in the United States, some thirty in number, are American inventions, and both of the foreign gauges have been improved upon, and are made in a superior manner here.

The passage between the boiler and the cylinder was at first opened and closed by means of a cock; the slide valve, modifications of which are now universally used, was the invention of Murray, of Leeds, England, in 1810. The piston was at first packed with hemp, saturated with grease; the brass rings, now used, were invented by Murdock & Aiken, of Glasgow, in the year 1813. The paddle-wheel between two boats was first used by William Symington, in Scotland; but the side wheel, as now used, together with the screw propeller, were both made use of in the models by John Fitch. His first steamboat, however, was worked by oars, or paddles, after the same manner as an Indian uses them. The first boat that carried passengers, built by John Fitch in 1789, was propelled by a set of paddles at the stern. The North River, of Clermont—Fulton's first passenger boat—was driven by the

present form of side wheel; she made a successful trip in the year 1807.

One of the greatest improvements of steamboats with regard to speed was made by Robert L. Stevens, who added the false bow to a boat constructed by him in 1815. She attained the speed of 15 miles per hour, a great improvement over the North River (which only made four miles per hour), but seeming very slow at the present date, as contrasted with the time made at a trial trip of the Daniel Drew, in 1860, which was 22 miles per hour against the tide.

It is quite curious to follow the various improvements that have been made upon the steam engine, and to see how the present simple apparatus was settled upon. It required years of experiment before the crank was adopted, notwithstanding that the same device had been in use in the common foot-lathe for several centuries. It was finally adopted by Picard; but, after his invention, Watt patented a much more complicated method of transmitting the reciprocating into the rotary motion. This was called the sun and planet motion, and went out of use only after repeated trials with the crank. It is true that the latter was patented; and the fact that Mr. Watt wished to avoid another patent, had much to do with this persistent trial of an inferior device. In the use of the locomotive engine, also, it was only after years of experiment that it was realized that the traction of the wheel upon the rail was sufficient to propel the carriage not only upon a level, but also up a very steep grade.

On the line of the Pennsylvania railroad, beyond the town of Altoona, the track has an ascending grade over the mountains of over 100 feet to the mile, yet a passenger train of six or seven cars, with the assistance of two locomotives, surmounts the grade at a speed of nearly thirty miles per hour, and this, too, upon a road that lies coiled upon the side of the mountain like a huge serpent. So short are its curves, that the locomotive is quite visible from the fourth car during many parts of the ascent. No other nation in the world can show so great a triumph of civil engineering as this. The first road that was constructed at this place was worked by stationary engines, and the cars were drawn up by ropes and chains. This was a copy of European engineering; but American genius is destined always to rise superior to imitation, and it is, in fact, only when it so rises, and trusts to its own gigantic plans, that the true power of American character shows itself. The stolid English engineer imitates the Egyptians and the Romans, and piles stone upon stone, and iron upon iron. The American imitates nature, with whose great works he is in constant communion, and, like the spider, constructs a bridge light in appearance, but sufficiently strong to withstand the tempest and the storm, and bear with an easy vibration, double, nay, triple, the load put upon it. Only an appreciation of the grandeur of such a fall as that of Niagara, could fit a man to construct the bridge that spans its river.

But to return to the improvements in the steam engine itself. When we look at the combination of them, as at present in use, we cannot but feel the wonderful genius therein displayed. It is but a few years since the steam engine, although vastly superior to horse power, was a cumbersome and expensive machine both to construct and repair; and although it is at present far from being perfect, yet the difference in its first cost, and the amount of fuel it uses for the same effect, is astonishing. Stand and look at some of our immense stationary engines, and see how noiselessly and steadily they turn the ponderous wheel! One would think a child's power could stop it. Then pass on, and on, through the groaning mill, and see the labor of thousands of men performed by this untiring giant. It is only after seeing the work he accomplishes, you can realize his strength. Stand upon the western prairie at night. The moon silvers a twin track that glistens far into the darkness; soon you hear a distant hum that grows upon the ear, and detect a faint spark that brightens as you gaze; anon the sound increases, and the eye of the iron horse overpowers the moon's pale gleam; he sees you, and screams his shrill warning. Who can help starting as he rushes by, or not feel as though steam itself were personified. Mark the groaning train, with its living freight, tearing madly through the darkness, bearing absent friends to the loved at home, or perhaps good news from the beloved afar.

Again, stand upon the Battery, at New York, and watch the almost countless fleet of steamships, steamboats, propellers, and tugs; some moving steadily toward the Narrows, as though conscious and proud of a power that can span the ocean in so short a time; others plashing and dashing madly

about, or clinging to some gigantic ship, and tugging manfully at its side, when old Boreas has left it helpless; others, again, in holiday attire, bearing a happy throng over the glad waters, and tuning the voice of this giant slave into fitting melody for the joyous hour. Here comes the Sound steamer, a floating palace fitted up in almost regal elegance, drawing but little water, and yet a staunch sea-boat, large, and, to the foreign ship-builder, apparently top-heavy, yet fast as the racehorse, and frequently tried by the stoutest gales. Up and down both rivers ply the ever busy ferry-boats — movable bridges, ever crowded with passengers. Did Fulton's wildest dreams ever picture a scene like this? Did John Fitch ever imagine a triumph so wonderful? Yet it is all the work of steam; and to them we owe, in part, the bands by which we hold this half-tamed Titan. Not only are these steamers propelled by steam, but his aid is called in both to load and unload them, and, in the hour of danger, steam works at the pumps with untiring hands. Not alone in the large manufactory, the gallant steamer, and the rushing car, does the vapor of water show its strength and usefulness, but thickly strewn about our cities and villages, delving in the mines, driving the rattling press, it helps all trades, and multiplies the power of man a thousand fold. Cities have sprung up under its magic touch, and everywhere we see traces of the king of motors—steam.

And to whom are we indebted for all this improvement, this immense power? Mainly to the American inventor, and our patent laws. It is not too much to say that one-half of the patents issued at the United States Patent Office for the last twenty years related either directly to the steam engine, or to machines intended to be driven by it; nearly all of them patented by citizens of the United States. The use of steam expansively was an English invention, but it is doubtful whether it was profitably used until improved upon in America. American locomotives have borne off the palm wherever they have been brought into contact with those of other nations. In ocean steamers we may be second, but the reason is plain: foreign builders have the assistance of rich and powerful governments, while our own success is entirely due to private enterprise, with a limited amount of capital.

As for steamboats for rivers and lakes, to which our immense inland navigation has turned the attention of our mechanics, we are far ahead of our rivals. The Yangtsze and Peiho, built for the Chinese coast, have never been equalled by England, as is sufficiently plain from the following China overland trade report, written by one of their own countrymen:—

"Steamboat builders in England, and Scotland, too, are certainly the most adroit 'shavers' living. They turn out so many miserable botches, that really we think a very great majority of the community would, were they 'going into steam,' resort to the United States. As far as river navigation is concerned, our attempts to compete with Jonathan are simply absurd, as those who own English river steamers here at present, must, ere this, have discovered to their cost. But, even in sea-going steamers, 'if the proof of the pudding be in the eating,' we should wish to know where the British steamers are, which are as swift, as safe, as commodious, as serviceable, or as economical in expenditure of fuel, as the Yangtsze or the Peiho? We maintain that every boat sent out here from England or Scotland, on China account, whether for coast or the river, has either been a miserable failure, or a glutton for fuel. We do not make one exception. We do not like to mention names, as we are averse to depreciate people's property, but we confidently leave it to every unfortunate sufferer to say whether or not we are correct in our statement.

"We, of course, except the P. & O. Company, as they seem to have a secret plan of constructing boilers, which makes them last as long as the boat; that is, for an indefinite period. We declare one never hears of any thing occurring to one of the company's boilers, nor any of their boats being laid up to have a new one, or the old one mended.

"We will take, for instance, the Chevy Chase, which vessel, we believe, cost on the Clyde about three times the sum that the Yangtsze cost at New York. Now the Yangtsze has been running nearly three years hard upon the coast, making unprecedentedly swift passages, and never was docked until the other day. The Chevy Chase will not carry so much as the Yangtsze, nor has she as good accommodation; but she burns twice as much coal, and, in a race between this and Shanghai, would be sparingly backed. She is about as strong again and as heavy

again as there is the slightest occasion for; and has clearly twice as much power as she can bear, for the weight of it sinks her. She is a very shallow craft, and her deck is so near the bottom, which contains an enormous mass of iron, that compasses will not act, and it becomes dangerous to run her in thick weather. She will bring grief to the hearth, but never grist to the mill; and the sooner she is altered the better. She should be made into a screw propeller, and a suitable vessel built for the valuable and powerful machinery now fitted in her. With a screw, and a spar deck fore and aft, she might be rendered serviceable yet. If the beams, etc., of the spar deck were constructed of wood, and the compasses put on an elevation, they would act well enough; they are at present neutralized by their proximity to a prodigious mass of iron.

"The American boilers, though not so durable as ours, are much better adapted to economy of fuel. Coal, in the United States, costs as many dollars as it does shillings in England. Economy of fuel is, therefore, more studied than with us, space being sacrificed. Our short tubular boilers send half the heat into the chimney, while the long flue boilers of the Americans absorb the heat pretty much in making steam. The difference is very great, and well worth the subject of an inquiry.

"Our engineers are such a pig-headed, self-satisfied, conceited set of people, that, until they see their trade gone, and their crotchets explode, they will not believe their own eyes. We are not venturing on opinions, so much as stating results; and too many here can corroborate the sad experience we unfold."

Having spoken thus, in general terms, of the steam engine, it may not be amiss to give a description of the simplest form thereof, by describing its component parts in terms easy to be understood and remembered. A steam engine consists, then, of a *cylinder*, closed at both ends, having fitted to it a piston, whose rod passes out at one end through a steam-tight hole called a *stuffing-box*. The piston consists of a skeleton, technically called a *spider*, having three brass rings made thin enough to yield to the inequalities of the cylinder as it wears, and forced against it by springs resting upon the spider, and held in place by a plate commonly called a *follower*. The steam is admitted to the cylinder on the side, at each end, through what are called the *ports*; the two ends of the ports are brought near each other at the point where they enter the *steam-chest*—a small box near the centre of the cylinder. These ports are alternately opened to the boiler and the atmosphere, by a sliding valve, that obtains its motion from what is called the eccentric, which is placed upon the main shaft. The piston-rod is fastened, at the external end, to a *cross-head*, which communicates its motion to the *crank-rod*, and through it to the main shaft. In stationary engines, working by a single cylinder, it is evident there will be two points at which the rod has no power over the crank; these points are called *dead centres*, and to overcome them the momentum of the balance-wheel is used. In the locomotive, two cylinders being used, they are set *quartering* (at right angles with each other), and the one overcomes the dead centre of the other. In the marine engine the motion of the wheel is continued by the action of the water, as the boat advances, and, consequently, no balance is required.

If, after a part of the steam has entered the cylinder, the induction valve be closed, the expansion of the steam would continue the stroke of the piston until the pressure became the same as that of the external air, or until the piston had reached the end of its stroke. Thus, if the pressure of the steam was eighty pounds per square inch in the boiler, and the valve was closed after the piston had made one quarter of its stroke, it is evident that the pressure would constantly decrease up to the end of that stroke, and that the average pressure would be less than the pressure in the boiler, but at the end of the stroke there would be but very little waste steam; in other words, the pressure remaining in the cylinder would not be in so great an excess over the atmospheric pressure as if the steam had followed the piston throughout its entire stroke. To show this more plainly, it must not be forgotten that steam at eighty pounds pressure is, in reality, steam at ninety-five pounds to the square inch, working against fifteen pounds (the atmospheric pressure), or a *difference of pressure* of eighty pounds; therefore, at the end of the stroke, the ninety-five pounds would have become twenty-three and three-quarters of pressure working against fifteen pounds atmospheric, or a difference of eight and three-quarters of pressure; so that, when the cylinder was open-

ed by its exhaust to the air, there would be only eight and three-quarters of a pound to the square inch thrown out into the air, and thus wasted, while you have had an average of sixty-seven pounds to the square inch throughout the stroke of the piston, working against fifteen pounds of atmospheric, or an actual *difference of pressure* of fifty-two pounds. Had you used fifty-two pounds of indicated pressure, following the full stroke of the piston, it is evident you would have thrown into the air the contents of the cylinder at that pressure, instead of at eight and three-quarters, as by the *cut-off*. This is, in brief, the theory of the cut-off; but, like many other improvements, it has been carried to an extreme, and has thus become a positive evil. In order to realize this, notice carefully the following: If steam, at thirty pounds per inch, as indicated, be used in a cylinder, cutting off at one-quarter stroke, what will be the pressure at the end of the stroke? Thirty is, as before shown, forty-five against fifteen: at the end of the stroke it will then be eleven and one-quarter against fifteen, or a back pressure of three and three-quarter pounds. Many people, who have found fault with cut-offs, have overlooked this important point, and have judged all cut-offs by an engine that was thus working at a disadvantage.

In explaining the cut-off, we have not taken into consideration the condensation of the steam from its expansion; and this is, of itself, a very important item of loss, as is also its increased friction; so that the actual gain from the use of a cut-off is not as great as it would theoretically appear.

Having thus stated some of the most important parts of a steam engine, we will now speak of some of its accessories. In order to give a uniformity of speed to the machinery driven by a steam engine, no matter how much the work it has to do may vary, the governor was invented: it consists, in its simplest form, of two balls revolving around an upright shaft, and suspended from its top by rods; if revolved with great rapidity, these balls are carried by their centrifugal motion to the greatest circumference that their rods will allow them; if moved slowly, they will assume their smallest circumference, and, by these motions, close or open the throttle, or, in the improved engines, vary the cut-off: thus controlling the speed of the engine, and keeping it always at nearly the same velocity.

In order to keep the boiler filled with water to the requisite level, one or more pumps are placed in connection with it, of a capacity to supply it, if only working part of the time. These pumps should always be provided with a *pet-cock*, which, when opened, will show whether the pump is doing its duty, as the valves of any pump are liable to become clogged and useless. On the locomotive engine the casual observer will notice that the engineer frequently tries these cocks, which are placed upon the side of the engine, and, in fact, that he sometimes tries them to the detriment of dandified-looking individuals, who approach too close to the iron steed. The pet-cocks are not, however, as much used as they should be, and, in fact, are very frequently left out altogether in the construction of the stationary engine. The safety valve, as at present in use, has a great many faults: it was originally the invention of Denis Papin, of France, and was constructed by him in his experiments with what was called Papin's steam digester—a machine for dissolving bones, etc. It consisted, as at first constructed, of a small round plate covering a hole, and held in its place by a weight suspended from a lever, whose fulcrum rested upon the plate. But little improvement has been made upon this simple device; it is now tapered, to fit a counter-sunk hole, and possesses the advantage of being more difficult to calculate. But one of its chief faults is in the fact that the point of contact between the lever and valve is so large, that its wear creates a constantly varying leverage. This could be obviated by making the point of contact a knife-edge instead of a half-inch pin. Another disadvantage in the common safety valve is the fact that the engineer has the power of weighting it to an unlimited extent. We have seen this difficulty obviated by an American invention. The weight is suspended in the boiler directly from the valve, and consists of the greatest weight the boiler should ever be allowed to carry. The lever is now so applied, that its tendency is to always lighten the valve, so that the more it is weighted the less steam can be carried.

CHAPTER II.

STEAMBOATS.

In looking over English works upon steam, we cannot help noticing the truth of Dr. Lardner's remarks: "England has been so dazzled by the splendor of her own achievements in the creation of a new art of transport by land and water within the last thirty years, as to become in a measure insensible to all that has been accomplished in the same interval and in the same department of the arts elsewhere." Not content with the praise other nations have ever been willing to give her for the invention of the steam engine, she also wishes to rob John Fitch of the only reward we can now give him for a life devoted to the steamboat. It is true that her arguments are aided to this end by the writings of some Americans who have endeavored to prove Fulton as the first practical steam navigator, thereby putting the date of this invention some twenty years later. But the time is fast approaching when the true inventor will be acknowledged by his countrymen, and the man who prophesied so truly that "this will be the mode of crossing the Atlantic in time, whether I shall bring it to perfection or not; steamboats will be preferred to all other conveyances, and they will be particularly useful in the navigation of the Ohio and the Mississippi. *The day will come when some more potent man will get fame and riches for my invention*" —when this man, we say, will be honored as he should be by the millions who enjoy the fruits of his genius; when our school-books will place his name in connection with that of Fulton, and his biography will be found in every library; when his grave and the tomb of Washington will not bring a blush to the American cheek.

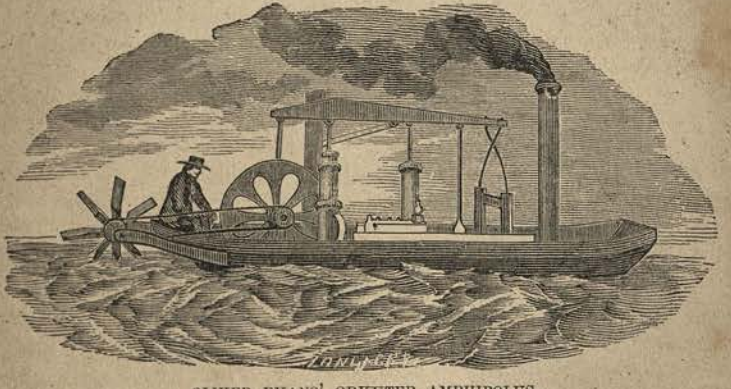
And are you not to blame, reader? Have you ever read the life of John Fitch, the American Watt—a life that remained sealed for thirty years by his own request, and now teaches a lesson of perseverance, under trials that few ever have to encounter? If not, it is a duty you owe your country and yourself to read it at once, and thus add another name to the tablets of your memory, already inscribed with those of Franklin, Fulton, and Morse.

The extent to which steam navigation has improved our country, is scarcely realized even by those who have travelled over it the most. The Hudson river, from the first voyage of the North River, Fulton's steamboat, up to the present time, has remained at the head of all competitors in river navigation. We had then two trips per week, each consuming from thirty to thirty-six hours; we have now four passenger boats per day over the entire route, and many making short trips, besides those used for towing barges and canal boats; the passenger boats making the entire trip of one hundred and fifty miles in from ten to twelve hours. The increased prosperity of New York, growing out of this immense traffic by steamboats alone, is very great, but even this is small when compared with the navigation of the Mississippi and the other western rivers. In 1856 there were over one thousand steamboats and propellers on the western waters, costing not less than nineteen millions of dollars, and of a carrying capacity of four hundred and forty-three thousand tons. Of these boats, the smallest was the Major Darien, of ten tons, built at Freedom in 1852; and the largest was the Eclipse, of one thousand one hundred and seventeen tons, built at New Albany the same year. Thus, on the western waters, in the short space of forty-five years, steam created a business that absorbed nineteen millions of dollars in steamboats alone.

Up to the year 1811, the only regular method of transportation had been by means of flat boats, which consumed three or four months in the passage from New Orleans to Pittsburg. The price of passage was then one hundred and sixty dollars; freight, six dollars and seventy-five cents per hundred pounds. The introduction of steam has reduced the price of passage between these two cities to thirty dollars, and merchandise is carried the whole distance for a price which may be regarded as merely nominal. Besides this great saving of time and money effected by steam navigation on these waters, the comparative safety of steam conveyance is an item which especially deserves our notice. Before the steam dispensation began, travellers and merchants were obliged to trust their lives and property to the bargemen, many of whom were suspected, with very good reason, to be in confederacy with the land robbers who infested the shores of the Ohio, and the pirates who resorted to the islands of the Mississippi. These particulars being understood, we are prepared to estimate the value and importance of the

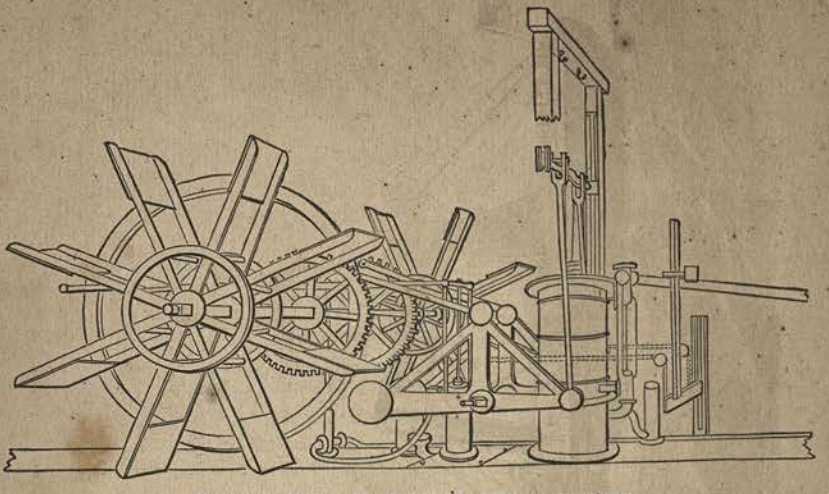
THE FIRST PROPELLER EVER BUILT.

Constructed by John Fitch, and experimented with by him on the Collect pond, New York city. The boiler was a twelve gallon pot, with a bit of truck-plank fastened by an iron bar placed transversely. This was in the year 1796.



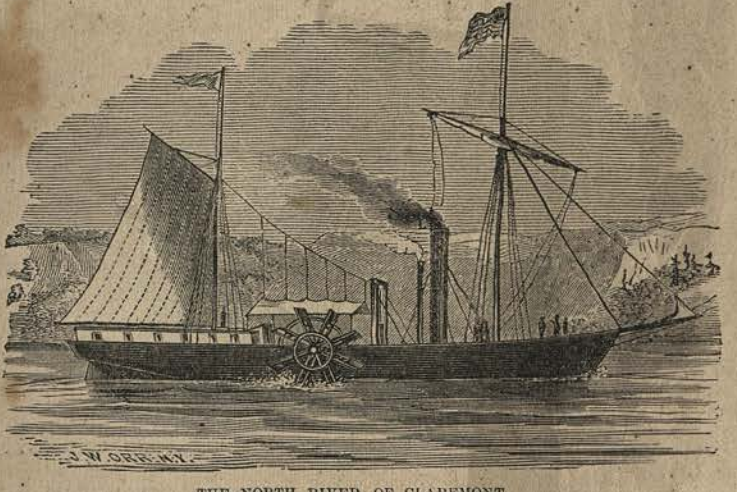
OLIVER EVANS' ORKUTER AMPHIBOLUS.

Thirty feet long and twelve broad. Cylinder five inches in diameter with a nineteen inch stroke. Constructed by Oliver Evans about the year 1804.



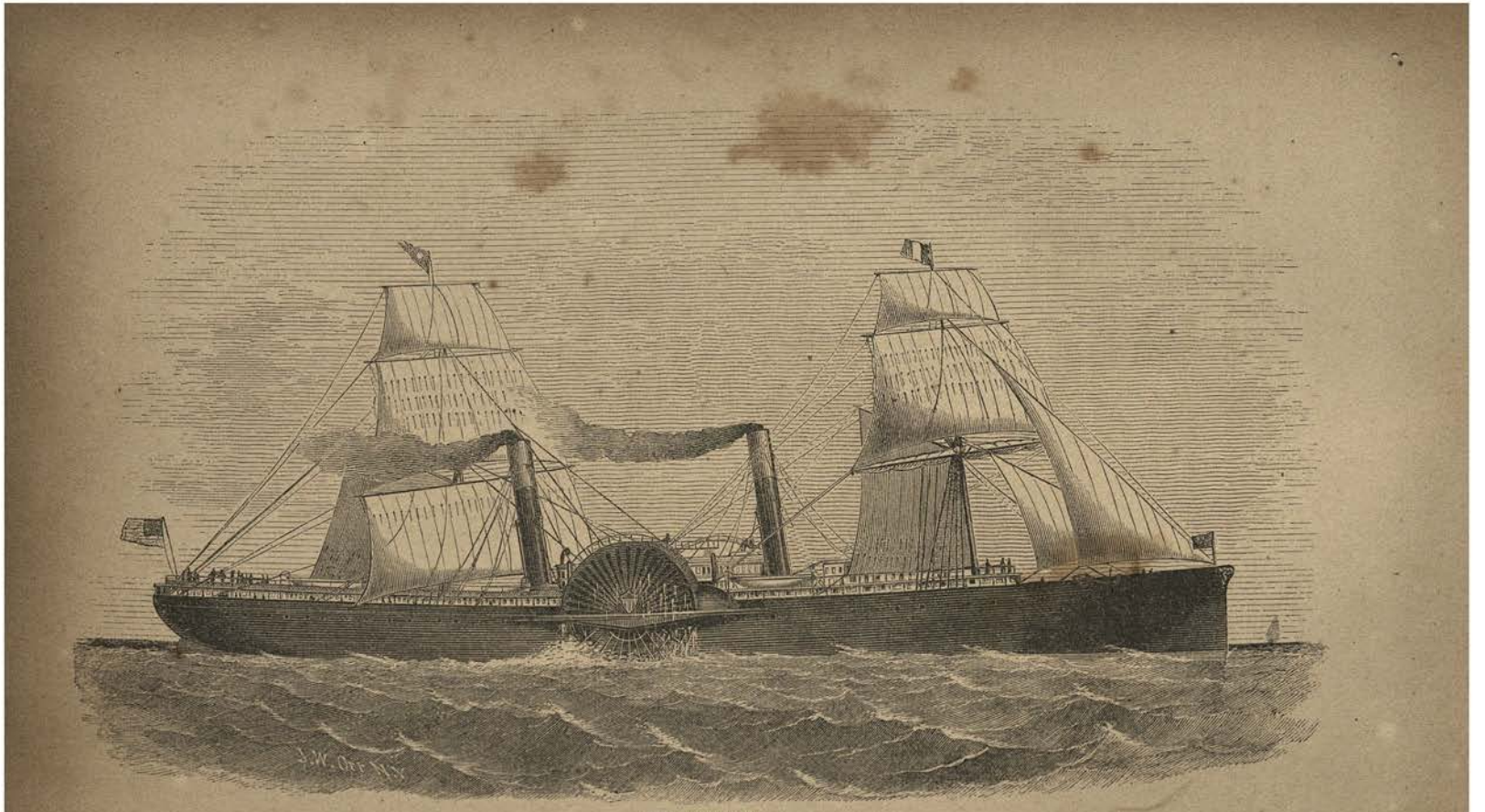
THE MACHINERY OF FULTON'S FIRST STEAMBOAT.

Imported from England where it was constructed in 1805. Wheels fifteen feet in diameter, cylinder twenty-four inches in diameter, four feet stroke.



THE NORTH RIVER, OF CLAREMONT.

Robert Fulton's first steamboat as she appeared after being lengthened in 1808. She was launched in 1807, and was run as a regular packet between New York and Albany. Speed four miles per hour, length 133 feet, beam 18 feet, depth 8 feet, tonnage 160.



THE ADRIATIC.

services which the steam engine has rendered to the commerce and prosperity of the western states.

In 1811, Messrs. Fulton and Livingston, having established a ship-yard at Pittsburg for the purpose of introducing steam navigation on the western waters, built an experimental boat for this service—and this was the first steamboat that ever floated on the western rivers. It was furnished with a stern wheel and two masts—for Mr. Fulton believed, at that time, that the occasional use of sails would be indispensable. This first western steamboat was called the Orleans; her capacity was one hundred tons. In the winter of 1812, she made her first trip from Pittsburg to New Orleans in fourteen days.

The first appearance of this vessel on the Ohio river produced, as the reader may suppose, not a little excitement and admiration. A steamboat at that day was, to common observers, as great a wonder as a navigable balloon would be at the present. The banks of the river, in some places, were thronged with spectators, gazing in speechless astonishment at the puffing and smoking phenomenon. The average speed of this boat was only about three miles per hour. Before her ability to move through the water without the assistance of sails or oars had been fully exemplified, comparatively few persons believed that she could possibly be made to answer any purpose of real utility. In fact, she had made several voyages before the general prejudice began to subside, and for some months, many of the river merchants preferred the old mode of transportation, with all its risks, delays, and extra expense, rather than make use of such a contrivance as a steamboat, which, to their apprehensions, appeared too marvellous and miraculous for the business of every-day life. How slow are the masses of mankind to adopt improvements, even when they appear to be most obvious and unquestionable!

The second steamboat of the west, was a diminutive vessel called the Comet. She was rated at twenty-five tons. Daniel D. Smith was the owner, and D. French the builder of this boat. Her machinery was on a plan for which French had obtained a patent in 1809. She went to Louisville in the summer of 1813, and descended to New Orleans in the spring of 1814. She afterward made two voyages to Natchez, and was then sold, taken to pieces, and the engine was put up in a cotton factory. The Vesuvius was the next; she was built by Mr. Fulton, at Pittsburg, for a company, the several members of which resided at New York, Philadelphia, and New Orleans. She sailed under the command of Captain Frank Ogden, for New Orleans, in the spring of 1814. From New Orleans, she started for Louisville, in July of the same year, but was grounded on a sand-bar, seven hundred miles up the Mississippi, where she remained until the 3d of December following, when, being floated off by the tide, she returned to New Orleans. In 1815-16, she made regular trips for several months, from New Orleans to Natchez, under the command of Captain Clement. This gentleman was soon after succeeded by Captain John D. Hart, and while approaching New Orleans, with a valuable cargo on board, she took fire and burned to the water's edge. After being submerged for several months, her hulk was raised and re-fitted. She was afterward in the Louisville trade, and was condemned in 1819.

In 1818, the first steamboat was built for Lake Erie and the upper lakes, at Black Rock, on the Niagara river, for the late Dr. I. B. Stuart, of Albany, N. Y., by Noah Brown, of New York city. She was a very handsome vessel, 360 tons burden, brig rigged, and her engine, on the plan of a Boulton and Watt square engine, was made by Robert McQueen, at the corner of Centre and Duane streets, New York city; her cylinder was 40 inches diameter, 4 feet stroke. The materials for making the boiler were sent from New York, and the boiler was made at Black Rock—9 feet diameter, 24 feet long—a circular boiler, with one return flue, called a kidney flue, seldom, if ever, carrying more than nine inches of steam. This steamer was called the Walk-in-the-Water, after a celebrated Indian chief in Michigan. Her engines were transported from New York to Albany by sloops, and from Albany to Buffalo by large six and eight horse Pennsylvania teams. Some of the engine was delivered in fifteen days time, and some was on the road about twenty-five days.

The trip from Black Rock, or Buffalo, to Detroit, consumed about forty hours in good weather, using thirty-six to forty cords of wood the trip. The price of passage in the main cabin was eighteen dollars; from Buffalo to Erie (Penn.), six dollars; to Cleveland, twelve dollars; to Sandusky (Ohio),

fifteen dollars; to Detroit, eighteen dollars. The strength of the rapids at the head of the Niagara river, between Buffalo and Black Rock, was so great, that besides the power of the engine, the steamer had to have the aid of eight yoke of oxen to get her up on to the lake, a distance of about two and one-half miles. In those days, the passenger and freighting business was so small, that one dividend only was made to the owners for the first three years from the earnings of the steamer. In 1821, in the fall, the steamer was totally lost in a terrible gale. On the coming winter, a new steamer was built at Buffalo, by Mr. Noah Brown of New York—a very strong, brig-rigged vessel. She was called the Superior, flush decks fore and aft; the first steamer, the Walk-in-the-Water, having had a high quarter or poop deck.

Compare the *time* and *expense* of travelling in those days with the present time! Mr. Calhoun (now living), the engineer of the Walk-in-the-Water, says, "Every two years I used to return to New York from Buffalo in the fall, and in the spring from New York to Buffalo. I have been *three* and *four* days, by stage, to Albany; never less than three days, and sometimes near five days; the stage fare was ten dollars to Albany. From Albany to Buffalo, I have been ten days in getting through; the shortest time was eight days; the stage fare through, was *twenty-one* dollars. *How is it now?* My usual expense in going to Buffalo from Albany was thirty dollars, including meals and sleeping." Such facts show the advantages we have obtained from the use of steam in our river navigation.

The boats that then plied upon the Hudson river, would not be sufficient to carry the passengers' baggage of the present day. The first boat was only 160 tons, while the New World, built in 1847, was of 1400. The latter has made the trip from New York to Albany in seven hours and fifteen minutes, including nine landings of say five minutes each; the actual running time being six hours and twenty minutes; distance, one hundred and fifty miles—performed by the North River in thirty-six hours.

The application of the steam engine to navigation, has been successful by three methods only: the side wheel, the stern wheel, and the propeller. The side wheel was known to the ancients, and was used in connection with a windlass, turned by men, as a means of propulsion, by the Romans, in their war galleys. It was first partially applied to steam navigation by Robert Fulton, but since his day it has undergone vast improvement. As at first constructed, it consisted of a double-spoked water-wheel, suspended by a shaft with no outside bearing, which shaft, being of cast iron, was very liable to break. The outside bearing and guard were subsequently invented by Fulton, as appears from his specification of patent. The wheels being totally uncovered, were found to throw water upon deck, and a dash-board was put up to prevent it, which was in time replaced by the present wheel-house. The paddle was next surrounded with a circular brace, or rim, as at present in use. In Fulton's first boat, the wheels could, at will, be disconnected from the engine, but this plan went out of use in order to simplify the machinery, after the crank shaft was adopted, connected directly with the engine. Various side wheels have been patented, that are so constructed as to prevent the lift of water as the bucket rises therefrom. One on the Richard Stockton appears to work well, but their complication, cost, and liability to get out of repair, have prevented their general introduction.

The stern wheel was first thought of by Jonathan Hull, of England, in 1736, as sufficiently appears from drawings thereof published by him; but it certainly was first practically applied by Robert Fulton, in the steamboat Orleans, of which we have already spoken. This wheel is now in almost universal use on our western rivers, as it is peculiarly adapted to boats drawing but little water. The wheel is suspended at the stern, and is sometimes covered with a wheel-house, but more frequently entirely exposed.

The propeller was first applied to a small steamboat built by John Fitch, and experimented with by him under the patronage of Chancellor Livingston, on the Collect Pond in New York. The propeller was a screw or worm. Great improvements have, however, been made in the screw, and to the English we are indebted for some of the most important. Captain Ericsson deserves great credit for his improvements in this respect. Among the finest of our propellers may be named the R. R. Cuyler and the Matanzas; the former is of wood, her total length is 240 feet; she is 33 feet wide, and has 24 feet depth of hold. She is furnished

with one direct-acting inverted condensing engine, the largest single engine as yet built for a propeller. Her cylinder has a diameter of 70 inches and 48 inches stroke. She is furnished with two return tubular boilers 13½ feet wide, 17 feet long, and 14 feet 4 inches high, with separate chimneys and separate connections to each boiler.

The Matanzas is the first steamer, whose hull is entirely of iron, that has ever been constructed in the United States. Her frame is of angle iron, with reverse bars also of iron; her keel is of solid iron, 3 by 9 inches, as are her beams and deck knees. She is clipper built, 900 tons burden; her dimensions are—length 210 feet, keel 200 feet, 30 feet beam, depth 20¼ feet. This beautiful propeller, as all her visitors have unanimously called her, was built at the Delamater Iron Works, under the direction of Mr. J. W. Caper, and is the first iron ship constructed at that shop. Her engine is an inverted cylinder, 56 by 44 inches, of the same pattern, although smaller, as that of the R. R. Cuyler, and was designed by the same engineer, Mr. John Baird, chief engineer of Cromwell's line.

The chief advantage claimed for the propeller over the side wheel, is the fact that in sea-going vessels the latter rarely possess an equal immersion, and consequently are constantly varying their purchase upon the water, whereas the propeller is always acting, or nearly so. The disadvantage of the propeller is the increased speed of the engine; this was at first overcome by gearing, but the plan is objectionable on account of breakage and friction. The true form of a propeller is not yet decided, and probably we shall soon see many vast improvements both in its construction and the application of the engine that drives it. In war vessels, the propeller is less liable to be damaged by shot than the side wheel, and as an auxiliary for the sailing vessel, it is far preferable to the latter. Various devices have been adopted to disconnect and take in the propeller when using sails, but the use of two arms instead of four has in a great measure obviated the necessity so to do. Propellers have been tried with success on the Raritan canal, and are now extensively used there; their cheapness, as compared with the side wheel, will always recommend them for small vessels. Whether the propeller will ever entirely supersede the side wheel is still a question; that they are cheaper in connection with sails as freighters no one questions, and it is possible that they may eventually be so improved as to eclipse the side wheel in speed; but this we very much doubt. They are, however, as yet comparatively in their infancy, and time alone will prove them.

Among sea-going side wheel steamers, the Americans may point with pride to the Adriatic, the largest steamer afloat except the Great Eastern; she measures 350 feet in length, 50 feet beam, and is about 5,000 tons burden. She was modelled and built by the late George Steers, and is a perfect vessel in appearance, appointments, speed, and every other respect. Her engines were built at the Novelty Works; her total cost was over a million of dollars. She has two oscillating engines, 101 inches in diameter by 12 feet stroke, and carries 25 lbs. of steam; her paddles are 40 feet diameter, floats, 3 by 12 feet; she has eight vertical tubular boilers, with 30,758 square feet of heating surface. She is truly a magnificent ship, and will compare favorably with any steamer in the world, not excepting the Great Eastern, that mammoth—we had almost said blunder.

Of our steam navy, the first commencement of which was the steam battery Fulton the first, built under the personal supervision of Robert Fulton, we can only say that it is small but efficient; steam in the navy is now a positive need, and we hope to see our force largely increased. The steam engineers in the United States navy are second to none in the world.

The use of the donkey engine or auxiliary pump, has been adopted in nearly all of our steam vessels, and is a decided improvement over the old method of filling the boilers by the main engine, as it obviates the difficulty of working the wheels while lying at the wharf, or stopping from any cause. The *sages* who managed the Great Eastern have thrown out the "donkeys," probably because they think there are sufficient for all purposes among the directors.

The use of coal in our steamers is now universal upon the Atlantic coast and rivers. John E. Mowatt, the first to establish the tow-boat business, was also among the first to burn coal. His boat, the Henry Eckford, was fitted up for that purpose, but the want of a sufficient draft was the cause of its abandonment after several trials; this was in 1825. A few years after, Robert L. Stevens tried a blower on his crank boat, the North America. His first blower was of rude construction, being made of planks, and placed

directly in front of the furnace, under the doors. After his success, the blower came into general use both for coal and wood; but improvements in furnaces have now, in a measure, superseded its use. Mr. Stevens tried several expensive experiments, and many of them proved of value only as lessons to the engineer. While experimenting upon the blower, he caused to be constructed a spiral fan in the chimney, but abandoned it after one or two trials. Placing the boilers on deck was his invention, as also the false bow that made so great an improvement in speed. The present open work walking-beam is also ascribed to him; in fact we may safely say that Robert L. Stevens did more than any other man toward the improvement of the steam engine.

When steam was first used, great fears were entertained of explosions, and dangers by fire; this was increased by the explosion of the steamboat Washington. This happened June 9th, 1816. She was the largest and finest boat that floated on the western waters. Her commander, Capt. Shreve, was skilled and experienced in all the duties of his calling; her machinery was all presumed to be in the best possible order, and no human foresight could have anticipated the fatal event. The boat left Marietta, Ohio, on Monday, June 7th, and on the afternoon of the following day came safely to anchor off Point Harmar, where she remained until Wednesday morning. The fires were now kindled, and other preparations made for continuing the voyage down the Ohio; but a difficulty occurred in getting the boat into a proper position to start the machinery. While laboring to effect this object (the boat having, in the meantime, been carried by the force of the current near the Virginia shore), it became necessary to throw out a kedge anchor at the stern. Shortly after, all hands were called to haul in the kedge, and while there collected together, the end of the boiler nearest the stern was suddenly blown off, and a column of mingled water and steam was thrown among the crowd, killing a number upon the spot, and inflicting the most frightful injuries on the remainder. The captain, mate, and several others, were blown overboard, and, with the exception of one man, were afterward rescued from the water, and found to be more or less injured by the scalding water and the scattered fragments of the boiler.

At Harmar, a neighboring town, the inhabitants were alarmed by the sound of the explosion, appearing, as it did, to shake the earth. A number of citizens—among whom were several physicians—rushed to the boat to ascertain the extent of the calamity. Language is but feeble to explain the misery and torture which presented itself to their view. Strewn about the deck were the mangled and writhing forms of human beings, filling the air with screams and groans, while others, more fortunate, had ended their sufferings in death. Those who experienced the greatest pain, apparently, were injured by inhaling the scalding steam, which is agonizing, beyond all the powers of imagination to conceive. The cause of this explosion is not exactly known, but it is supposed to have been from over-pressure, owing to the displacement of the valve weight, which had accidentally slipped to the end of the lever.

This accident, as we said before, added to the general prejudice against steamboating, and caused a great excitement among the inhabitants of that region; people being oblivious of the fact that in proportion to the passengers carried by steamboats up to that date, there had been much less accident and danger than by the original conveyance of barges and flat boats. Still, there was a great deal of mismanagement, resulting from ignorance, in our first steam vessels, and the general introduction of high-pressure engines, without the proper increase of strength in the boilers, caused many serious accidents, that in time drew the attention of Congress to the subject. Several laws were passed; but it was not until quite a late period that the present comparatively perfect system of inspection was matured by our government.

In the year 1852, an act was passed by Congress, containing provisions against fire, regarding pumps, boats, life preservers, the transportation of dangerous articles, etc. This act also provided for an inspector of boilers in each district, whose duty it is to test all the boilers in his district, used on board of vessels carrying passengers, once when first constructed, and at least once a year thereafter. The Board of Inspectors were also empowered with the examination of engineers, which duty is set forth in the following section: "Whenever any person claiming to be qualified to perform the duty of engineer upon steamers carrying passengers, shall apply for a certificate, the

Board of Inspectors shall examine the applicant, and the proofs which he produces in support of his claim; and if, upon full consideration, they are satisfied that his character, habits of life, knowledge, and experience in the duties of an engineer are all such as to authorize the belief that the applicant is a suitable and safe person to be entrusted with the powers and duties of such a station, they shall give him a certificate to such effect, for one year, signed by them, in which certificate they shall state the time of the examination, and shall assign the appointee to the appropriate class of engineers."

It was also provided that nine supervising inspectors should be appointed by the executive, to carry out the provisions of the act. Since the passage of this law, steamboat explosions on the Atlantic coast have become almost unknown, and have greatly decreased in the west. With competent inspectors this law is invaluable, and we hope to hail the day when a similar act is passed in every legislature, touching locomotive and stationary boilers.

No one who looks at the immense amount of business done by steam vessels, will question the advantages obtained by the application of steam to navigation, still this branch of commerce is as yet in its infancy, and it is our belief that not only will steam supersede sails entirely, but also that the laborious occupation of rowing will eventually be mainly done by steam. It is unquestionable that boats requiring four men to pull them can, even now, be much more economically worked by machinery, and certainly run much faster. Their cost need not exceed five hundred dollars. For such small craft the propeller is better fitted than the side wheel. There is a boat of this description now running in the harbor of Norfolk, Virginia, and capable of carrying twelve passengers at eight miles per hour, at the expense of seventy-five cents per day for fuel, and the wages of one man, who can easily do the work and steer the boat. This boat carried passengers to the Great Eastern, when she lay off Old Point Comfort, and appeared like the minnow beside the whale.

We have already stated that John E. Mowatt was the first to introduce the tug business on the North River. This was Jonathan Hull's idea; he never dreaming that large vessels could be provided with propelling power, both on account of its weight, the weight of fuel for a voyage, and the danger from fire. This branch of steam navigation has proved very lucrative. Within the past few years the propeller has here also been substituted. Philadelphia, we believe, was the pioneer in this enterprise, and most of the propeller-tugs were built in that place. We will conclude this chapter with the following statement of the tonnage of steam vessels belonging to the several ports of the United States in 1859, as published in the "Report on Commerce and Navigation":—

New York	120,598.09
New Orleans	75,789.91
St. Louis	54,515.64
Pittsburg	40,550.08
Buffalo	42,464.04
Detroit	33,005.12
Louisville	29,626.72
Cincinnati	25,668.31
Mobile	28,898.52
Philadelphia	22,238.50
Cleveland	21,720.73
Baltimore	19,260.83
San Francisco	10,214.94
Boston	9,998.52
Chicago	7,651.45

The total steam tonnage of the United States, for the year ending 30th of June, 1859, was 676,004 83-95 tons.

CHAPTER III.

LOCOMOTIVES.

Our second chapter referred more particularly to the application of steam to navigation. In this, we shall endeavor to set forth its advantages in land transportation. Among the earliest experiments upon this subject in America, were those by Oliver Evans, of Philadelphia. The following is his account, published in 1804:—

"I constructed for the Board of Health of Philadelphia a machine for cleaning docks, called the Orukter Amphibolos or Amphibious Digger. It consisted of a heavy flat-bottomed boat, thirty feet long, and twelve feet broad, with a chain of buckets to bring up the mud, and hooks to clear away sticks, stones, and other obstacles. These buckets are wrought by a small steam engine set in the boat, the cylinder of which is five inches diameter, and the length of stroke nineteen inches. This machine was constructed at my shop, one mile and a half from the river Schuylkill, where she was launched.

She sunk nineteen inches, displacing five hundred and fifty-one cubic feet of water, which, at 62.5 pounds, the weight of a cubic foot, gives the weight of the boat thirty-four thousand four hundred and thirty-seven pounds, which, divided by two hundred and thirteen, the weight of a barrel of flour, gives the weight of one hundred and sixty-one barrels of flour that the boat and engine is equal to. Add to this the heavy pieces of timber and wheels used in transporting her, and the number of persons generally in her, will make the whole burden equal to at least two hundred barrels of flour. Yet this small engine moved so great a burden, with a gentle motion, up Market street and around the Centre Square, and we concluded from the experiment that the engine was able to rise any ascent allowed by law on turnpike roads, which is not more than four degrees."

After giving a comparison of the merits of steam and horse power, for moving carriages on common roads, Evans says: "Add to all this that the steam wagon consumes nothing while standing, will roll and mend the roads, while the horse wagons will cut them up. Upon the whole it appears that no competition could exist between the two. The steam wagons would take all the business on the turnpike roads. I have no doubt but you will duly appreciate the importance of such an improvement, and conceive it to be your interest to appropriate the sum necessary to put it in operation. I have invented the only engine that will answer that great purpose, as well as many others for which power may be wanted. It is too much for an individual to put in operation every improvement which he may be able to conceive or invent. I have no doubt that my engines will propel boats against the current of the Mississippi, and wagons on turnpike roads with great profit. I now call upon those whose interest it is, to carry this invention into effect. All which I respectfully submit to your consideration."

Thus it will be seen that Mr. Evans not only practically applied steam to locomotion, but fully realized the advantages of his invention. The introduction of the railroad prevented the improvements that would naturally have followed so great an invention, and but little has since been done, until within the past three or four years.

Mr. Fisher has been one of the most successful in his improvements; his first experiment was in 1853, when he built a small carriage for four persons, which weighed, empty, about one thousand four hundred pounds. The cylinders were ten by four; boiler, thirty feet of surface, only twenty feet of which could be reckoned effective, or one foot of surface to about one hundred and ten pounds of total weight. It outran horses, in night races, on the Broadway pavement, and ran at a moderate speed on cobble pavements, but had not steam enough for common roads.

The next trial was in 1858, on two steam fire engines, the J. C. Cary and J. G. Storm, the carriages and engines of which were built from his design, the boilers and pumps being designed by others. These engines had heavy boilers and apparatus, and could not be regarded as steam carriages, but only as a demonstration of the practicability of working by steam. Their cylinders are fourteen by seven and a half inches; wheels, five feet; the Cary boiler four hundred and eighty feet of heating surface; that of the Storm three hundred and eighty; weight of the Cary, empty, fifteen thousand six hundred and thirty-six pounds; the Storm somewhat lighter. These engines ran well on pavements, and when fairly in motion could run on soft ground at six or seven miles per hour. The next experiment was by Mr. Fisher in 1859, when a carriage was built, which is not yet finished. Its cylinders are fourteen by seven inches; wheels, five feet; boiler, one hundred and sixty feet of surface; weight, with water and eleven men, estimated at twelve thousand pounds, or seventy-five pounds to one foot of heating surface. Two gentlemen timed it on an evening trial trip; one reported that it ran between two mile stones in two minutes and forty seconds; the other reported it within three minutes. The road was gravel, rather loose and soft on the surface.

As we have before stated, the introduction of railroads turned the attention of our mechanics to them, and steam carriages were abandoned. The railway itself does not come within the compass of our article; we will state, however, that its origin is unknown, as the remains of a stone tram-road have been found among the ruins of Thebes.

Thirty years ago they were still discussing the advantages of canals as compared with railroads in this country; it is, however, somewhat singular that, with the exception of a mile or two of canal near Cambridge, constructed by the Romans, England had in-

troduced the entire principle of railroads long before she took up canals. As long ago as 1776, and possibly thirty years prior to that time, England had wooden rails in some of her collieries. It was not, however, until the year 1825 that the subject was prominently brought forward. The railway project from Manchester to Liverpool was the cause of this new impulse. The rails, prior to 1776, were of wood, placed about four feet apart on sleepers; these wooden rails were then covered with iron plates, and cast iron wheels were adopted instead of the wooden ones that had been used up to this time. In 1790, the edge rail was invented. From 1802 to 1806, the first effective experiments were made with the locomotive engine. It was not, however, supposed possible that the friction or adherence of the plain wheels of such carriages upon the rail could be sufficient to allow any great weight to be drawn after them, and, therefore, the cumbersome appendage of cog wheels and ratchet wheels, continuous and endless chains, propelling levers, etc., etc., continued to perplex the minds of engineers until about 1814, when it was first discovered that the adhesion of the locomotive carriage, with its plain cast iron wheels, was adequate for every purpose on ordinary railways. The improvement consequent upon this was effected by Mr. Stephenson in the north of England, and for a long time his engines, with unimportant alterations, were used where fuel was cheap. Those locomotives drew about one hundred tons on a level, at four miles the hour, performing the work of about sixteen horses. Their weight was about ten tons, and cost about sixteen thousand dollars.

The first railway in the United States was built from Milton to Quincy, Mass., a distance of two miles, in 1826. The Baltimore and Ohio was the first passenger railroad; it was opened in 1830, a distance of fifteen miles, with horse power. Next in the order of time came the Mohawk and Hudson, from Albany to Schenectady, sixteen miles; opened for travel also with horse power. The first locomotive engine upon a railway in this country, was built at Stourbridge, England, for the Delaware and Hudson Canal Company, and imported by Mr. Horatio Allen. This engine was called the Lion. Mr. Allen, in a speech not long since, gives a graphic account of the first trip: "It was in the year 1828, on the banks of the Lackawaxen, at the commencement of the railroads connecting the canal of the Delaware and Hudson Canal Company with their coal mines; and he who addresses you was the only person on that locomotive. The circumstances which led to my being alone on the engine were these: the road had been built in the summer; the structure was of hemlock timber; the rails of large dimensions, notched on caps placed far apart; the timber had cracked and warped from exposure to the sun. After about three hundred feet of straight line, the road crossed the Lackawaxen creek on trestle-work, about thirty feet high, with a curve of from three hundred and fifty-six to four hundred feet radius. The impression was very general that the iron monster would break down the road, or it would leave the track at the curve and plunge into the creek. My reply to such apprehensions was, that it was too late to consider the probability of such occurrences; that there was no other course than to have a trial made of the strange animal, which had been brought here at great expense; but that it was not necessary that more than one should be involved in its fate; that I would take the first ride alone, and the time would come when I should look back to the incident with great interest. As I placed my hand on the throttle-valve handle, I was undecided whether I would move slowly or with a fair degree of speed; but believing that the road would prove safe, and preferring, if I did go down, to go handsomely, and without any evidence of timidity, I started with considerable velocity, passed the curve over the creek safely, and was soon out of hearing of the vast assemblage. At the end of two or three miles I reversed the valve, and returned without accident; having thus made the first railroad trip by locomotive on the western hemisphere."

The first locomotive engine ever built in the United States, was built at the West Point foundry, New York, under the direction of Samuel Hall, for the South Carolina railroad. This engine blew up shortly after it commenced running, and another was built to replace it. In 1831, the De Witt Clinton was built at the same foundry for the Mohawk and Hudson (New York Central) railroad; this engine weighed four tons; it was run without load at the rate of forty miles per hour. Cylinders, five and a half inches in diameter—stroke, sixteen inches; four coupled wheels, four and a half feet in

diameter. The boiler was cylindrical, with a large dome in the centre, and contained some thirty flues. In January of the same year, the Baltimore and Ohio railroad offered four thousand dollars for the best anthracite coal-burning locomotive, weighing three and one half tons, and capable of drawing fifteen tons, fifteen miles per hour on a level, with a steam pressure of not more than a hundred pounds to the square inch. The conditions were filled by an engine built by Phineas Davis, of York, Pa., in June, 1831. This engine had an upright boiler and cylinder. William T. James, of New York, who had already constructed a steam carriage in 1829, finished a locomotive in 1832; this engine was employed on the Harlem railroad, with success, for a time, but was eventually sold to the Baltimore and Ohio road, where it exploded in 1834. This engine was provided with a "spark arrester." In January, 1833, M. W. Baldwin, of Philadelphia, still one of our best locomotive builders, built the Old Ironsides, for the Philadelphia and Germantown Railroad Company. This engine weighed five tons, and was said to have been run at the rate of sixty-two miles per hour. Mr. Baldwin introduced the outside connection engine, thus doing away with the crank axle, and placing the cylinder more under the eye of the engineer.

It would be tedious to follow the construction and alterations in the various locomotives that were built by different manufacturers in the United States. We will, however, mention the most important improvements.

The truck frame, in front of the engine, was first used by Adam Hall, of the West Point foundry, in 1832, on an engine called the Experiment. The four eccentrics were first used by William T. James, on his steam carriage; they were, however, patented by S. H. Long, of Philadelphia, in 1830, and first used on a locomotive in 1833; this was the Black Hawk, built by Long and Norris, of Philadelphia, the founders of the present locomotive shop known as Norris' works. The Norris engines were the first ever exported; this was brought about by the, at that time, extraordinary fact of drawing 19,200 pounds up an incline of three hundred and sixty-nine feet to the mile, the engine weighing but 14,370 pounds; on hearing of which, the Birmingham and Gloucester Railway Company ordered several engines for an incline upon their road, where they performed successfully. Since that time, engines have been exported to England, France, Russia, Germany, Egypt, and Chili. In the latter country there are eight American locomotives. The engines forwarded to Egypt, were built by William Mason, of Taunton; and for excellence of workmanship, style, and finish, will compare favorably with any in the world. There are, at present, twenty-nine American locomotives on German roads. Messrs. Winans, of Baltimore, furnished the majority of the locomotives sent to Russia. There are now some twenty-three locomotive shops in the United States. Most of the engines are, however, built in Philadelphia, and Paterson, N. J. Hinckley and Drury's, afterward called the Boston Locomotive Works, was established in 1840. The Lowell shop began to build engines in 1835. Rogers, Ketchum & Grosvenor, of Paterson, New Jersey, commenced building in 1837. This shop is still in full operation, under the name of the Rogers Locomotive Works. This shop made several material alterations upon the English type; they enlarged the boiler in proportion to the cylinder, established the link motion, and covered more effectually the cylinders and valve chests, to prevent radiation. Rogers, also, was among the first to adopt the full-stroke pump. The locomotives built at this shop have always found a ready market. Next in order was the Taunton Locomotive Company, established in 1847, by W. W. Fairbanks, a marine boiler maker from Providence, Rhode Island. Then John Souther, formerly of Hinckley's shop, started his works in South Boston, in 1848. In 1849, the Amoskeag Manufacturing Company entered the lists with some important improvements; they were followed by the Portland, Lawrence, and Wilmarth shops, and a few years after, by Mason, of Taunton, the East Bridgewater, and the Manchester locomotive works. But since 1857, the New England locomotive shops have done but little of this kind of work; the Boston, Lawrence, and Manchester locomotive works have failed; the Amoskeag, Lowell, and Mason's shop at Taunton, have turned their attention to cotton and woollen machinery; and the business has gone almost entirely into the hands of the Paterson and Philadelphia shops. The causes of this change are various: prominent among them may be mentioned the manufacture of locomo-

"EUREKA" LOCOMOTIVE WORKS.

tives by railroad companies themselves, at their repair shops.

The manufacture of the locomotive engine had a good effect upon our machine shops, independent of the work it furnished; as in order to construct them a variety of improved tools were made, that have greatly added to the facility for turning out other machinery. These improvements are so marked that no one who is familiar with the machine shop can help noticing them.

Coal is now rapidly superseding wood as fuel for the locomotive. It is true that some of our first engines were coal-burners, but wood has been for years the principal fuel used. The American engine has several marked distinctions from the English; what most strikes the eye of the common observer is the *cab*, or house for the protection of the engineer; this is peculiar to our locomotive. The *smoke stack* is also very different in the wood-burning engine from that in use on coal-burners. The auxiliary pump is used on some of our engines, but not to so great an extent as it should be.

A first-class locomotive engine costs about ten thousand dollars, and an average taken from one of our largest roads shows a cost of about eleven hundred dollars per year for repairs. Locomotives in this country are built much too large for the work they have to accomplish, and the attention of our master machinists having lately been much attracted to this subject, it is to be hoped that some improvements in the weight will be made. A locomotive too heavy for the work it has to do, is not only more expensive in first cost, but in the greater wear of the road. A good locomotive can draw thirty times its own weight on a level, and a paying load should not exceed twenty-five tons; bearing this in mind, why build twenty-six ton engines? There are many parts of an engine now built much too heavy; the bell, dome-casings, and cabs, for instance. It is not necessary to greatly lessen the weight of the running gear, although in some instances this is much too heavy. Wrought iron in place of cast in some cases would be lighter and much better, and steel should be substituted for iron wherever possible. The speed over the American roads is not so great as in England, from the fact that the former have more and steeper grades, and have, besides, shorter curves, to say nothing about their construction being much less expensive. Sixty miles per hour has been made upon our roads, however, but thirty is nearer an average, while in England seventy miles has frequently been attained.

Dr. Lardner, in his lately published "Economy of Railroads," thus endeavors to convey to the unpractised reader the enormous speed of a locomotive going at the rate of seventy miles an hour: "Seventy miles an hour is, in round numbers, one hundred and five feet per second, that is a motion in virtue of which a passenger is carried over thirty-five yards between the beats of a common clock. Two objects near him, a yard asunder, pass by his eye in the thirty-fifth part of a second; and if thirty-five stakes were erected by the side of the road, one yard asunder, the whole would pass his eye between two beats of a clock; if they had any strong color, such as red, they would appear a continuous flash of red. At such a speed, therefore, the objects on the side of the road are not distinguishable. When two trains, having this speed, pass each other, the relative velocity will be double this, or seventy yards per second; and if one of the trains were seventy yards long, it would flash by in a single second. To accomplish this, supposing the driving wheels seven feet in diameter, the piston must change its direction in the cylinder ten times in a second. But there are two cylinders, and the mechanism is so regulated that the discharges of steam are alternate. There are, therefore, twenty discharges of steam per second, at equal intervals; and thus these twenty puffs divide a second into twenty equal parts, each puff having the twentieth of a second between it and that which precedes and follows it. The car, like the eye, is limited in the rapidity of its sensations, and sensitive as that organ is, it is not capable of distinguishing monotonous sounds which succeed each other at intervals of the twentieth part of a second. According to the experiments of Dr. Hutton, the flight of a cannon ball was six thousand seven hundred feet in one quarter of a minute, equal to five miles per minute, or three hundred miles per hour. It follows, therefore, that a railway train, going at the rate of seventy-five miles per hour, has the velocity of one-fourth that of a cannon ball; and the momentum of such a mass, moving at such a speed, is equivalent to the aggregate force of a number of cannon balls equal to one-fourth of its own weight."

Some years ago a curious calculation,

showing one of the advantages of the steam locomotive, was made in England. "In 1853, 111,000,000 passengers were conveyed, each passenger travelling an average of twelve miles. Twelve miles of railroad are accomplished in half an hour, whereas the old stage coach required an hour and a half to get through the distance. The aggregate time thus saved for the above number of passengers is equal to *thirty-eight thousand* years." This was seven years ago, since which time the number of passengers carried has been nearly doubled.

Mr. Fleming, on the Mobile & Ohio railroad, and some other master mechanics, have adopted the plan of paying the engineers a certain fixed salary, and then giving prizes to those who save the most fuel to the mile run. It is also customary to place the inspection of wood to be used under the engineer's care, he having the choice of the stations at which he will take in wood. With these two regulations the company get better wood at the same price, as it is directly to the engineer's interest to carefully examine the quality, quantity, and price of every load of wood he takes on. So great has been the economy of this plan, that it is strange that every one does not adopt it.

Another important item in the running expenses of the locomotive is the oil and waste. The latter is used to wipe the machinery, not only on account of the looks, but to prevent its *gumming* up with oil and dirt. The average cost of oil, waste, and tallow, taken from some of our largest roads, is seventy-five hundredths of a cent per mile run; and as engines average some fifteen thousand miles per year, we have a total cost, in three small items, of one million dollars per year in the United States alone.

Before leaving the subject of steam locomotives, we wish to speak of the Dummy engine, or steam car for city railroads. We know that this use of steam has met with great opposition from all classes of men; but what are the arguments? In the first place they say: "Oh! the steam car is much more dangerous than horses." Why? "Because it is more difficult to stop, and it goes so much faster." What is the truth? It is much easier to stop a steam car than one drawn by horses, inasmuch as we have not only the same brakes, but the power of reversing the engine in an emergency. As to the cars being run faster, our laws against fast driving are as potent in the one case as in the other; and by Darker's arrangement, it is impossible for the car to go over a given speed—the governor being attached to the brake. The second argument against steam cars is that the noise and smoke will frighten horses. The noise and smoke can both be avoided, and it has been proved that horses are not more liable to start than at the sight of a buffalo robe. The argument as to expense has been entirely thrown aside; still, but few know the great advantage in this respect that steam has over horse power. A number of our lines average seven horses to a car (in Boston they average eight), in order to have the necessary relays; seven good horses for this purpose are worth, say, eight hundred dollars; the feed, care, and stable-room of each horse averages, say three dollars and fifty cents per week; so that a line with forty cars is under the enormous annual expense, for horse-care and keep alone, of $50,960! Now then for steam. The first cost of an engine and steam generator, with all the necessary appurtenances, will be no more, if as much, as the seven horses to each car. Keeping the engine in repair would incur no more expense than shoeing horses, renewing harness, etc. It would cost no more to replace them than to replace worn-out horses. The engines, to be of sufficient capacity to overcome our steepest grades, will consume eight bushels of coke per day (a high estimate), running sixteen hours, the price of which at present is five cents per bushel; but, supposing the extra demand to cause an advance of a hundred per cent.—which is hardly likely, for even a less increase in price would cause many private families and others to cease using it—the fuel expense in one year, to a company with forty cars, would be $9,984; making the difference in cost, in one year, between steam and horses, of $40,976. Think of it! $40,976 saved to a company with forty cars, in one year (over $1,000 per car), after putting down the fuel at double its present price. Coke is preferable, because it is clean to handle, ignites quick, emits no smoke, is light and cheap, and requires a much less draught than coal. To save cumbrous and useless weight as much as possible, it is proposed to carry very little fuel, except what is on the fire, nor unnecessary extra water either, the tank and bin to be replenished at the depot each trip, while waiting its time.

Were the different companies to offer, as an inducement, to reduce the fare to *three cents*, on condition that the community would permit the use of steam, they would annihilate all groundless opposition on the part of the masses, which is every thing with us; and the enormous increase of "short rides," occasioned by the reduction of fare, would make the receipts greater than at present; and as the saving in favor of steam is quite $1,000 a year per car, the value of the stock would be increased prodigiously. If there could be any serious objection urged against using steam, in this age of improvements, with the plans of safety here laid down, other than those suggested by "old fogyism," all the advantages we have enumerated would weigh little in its favor; but when it can be so arranged as to be actually safer than horse power, we think the time has come to put it thoroughly to the test, at all events.

Among the plans for city cars that have been suggested and built, we may mention those of Latta, of Cincinnati; Baldwin; Grice & Long; and Darker, of Philadelphia. Latta's engine is in a separate car from the passengers; Baldwin's has its machinery beneath the car, and its boiler in front; and Darker places his entire engine and boiler upon the roof, connecting with the wheels on the outside, near the centre. Grice & Long's car is thus fitted: the engines and boiler are on the front platform; the engines slightly inclined, and graded to the front axle; the axle being placed at the extreme end of the car, for the purpose of making the connection, and increasing the stability of the wheels. The boiler is of the ordinary vertical, tubular type; the after part of the car is finished with a self-adjusting, vibrating truck, for the purpose of turning the short curves of city roads. The running of this car has afforded the utmost satisfaction. With a full complement of passengers, it has ascended the heaviest railway grades in Philadelphia county; some of which exceed three hundred and seventy feet to the mile, embracing sharp curves. The whole arrangement is simple and compact; can be applied to the horse cars now in use, and will give them a greater number of seats than they now afford. These steam cars burn anthracite coal, and have open exhausts; thus avoiding the two most prominent objections urged against street locomotives, smoke and noise. The *American and Gazette*, of Philadelphia, describes a trip made last March in this car, from which we extract the following:—

"The road traversed is a very rough one, built cheaply of cast iron rails, which are shorter than those of wrought iron used in the city streets; and as the material is less durable, the joints are well worn, and the travelling good for dyspeptics. There are also some sharp curves and steep grades, which are calculated to test the power of a locomotive. But with all these difficulties the car made its trip in thirty minutes, against forty-five usually taken by the horse cars. It was really agreeable travelling, too, for the car was heated by steam pipes, so that it was as comfortable inside as in a parlor. There is no escape of smoke, as the engine consumes only anthracite, and uses up its own gas; nor is there escape steam, that being carefully provided against. Thus, when the locomotive is under full headway, there is no puffing or blowing, no wheezing to be heard outside, and, in fact, nothing to frighten a horse. On the road, all sorts of vehicles were encountered, drawn by every description of horse, from the thorough-bred to the common draught horse; they were passed at the ordinary pace and without stopping, but none of them took fright; and this settles clearly enough that the steamer will not frighten horses. The car is warmed in winter by steam pipes along the floor. Yesterday was a raw, disagreeable day, and we had occasion to observe that the car was comfortably warmed by these pipes. The temperature, too, may be increased or diminished, at the will of the engineer, an important consideration in our variable climate. In summer the steam car may also be kept cool by the same agency which heats it, by simply attaching a steam fan to the engine, the fan to be stationed in the centre of the roof of the car."

Thus much for the first experiment of any note that has been tried upon the street railroad. It was, in our opinion, a decided success, and should wake up our city railroad companies to action; this old war between horses and steam is renewed, but we hope it will soon have its final quietus.

We will conclude this chapter with an anecdote of the first engine introduced upon the Baltimore and Susquehanna railroad. This road was built to run with horses, and in some of the first circulars issued by the company, the road was spoken of as being

delightfully picturesque, winding among beautiful scenery, and forming a most interesting ride—rather different from the emperor of Russia's idea of a railroad, which he laid out with a ruler, by describing a straight line from Moscow to St. Petersburg. Against the wish of the president of the company an engine was imported from England in the brig Herald, about the year 1830, and was put upon the road under the management of an English engineer. While standing upon the track one day, fired up and ready to start, the president, who was absent on her arrival, came down to look at the strange animal. He was accompanied by one of the directors, who had already examined the iron steed and was desirous of exhibiting it to the best advantage. The engineer being temporarily absent, the two mounted upon the platform. "Thee sees, friend," said the director, "this lever; well, by drawing it toward thee (suiting the action to the word), the machine will retreat, and by pushing it from thee, it will advance; thus the competent man can handle it as readily as thee can drive a horse. If thee turns this little crank the steam will commence working, and the engine will start." And sure enough the engine did start, for the honest Quaker, in order fully to explain its action, had opened the throttle. Away went the iron horse, affrighting them out of all presence of mind, and increasing in velocity at each stroke of the piston, until it reached one of the picturesque curves that had so much delighted the president, where, with one bound, it left the track and turned a summersault down the embankment. Both parties were hurt, but most fortunately escaped with their lives.

CHAPTER IV.

STATIONARY ENGINES.

This is the oldest form, being but a modification of the first steam pumping engines; not being confined to space as in the locomotive and marine engine, these machines have admitted of a greater variation of form, and a better chance of artistic display than any other, consequently we have many instances of elaborate workmanship and a great variety of design. The majority of stationary engines in use may be divided as follows: the beam, the horizontal, the steeple, the oscillating, and the rotary engine. The beam engines are commonly low-pressure or condensing, and are mainly used for pumping, or where great power is required; the motion of the piston is communicated by the working-beam to the pump or crank-shaft at the opposite side of the machine. The horizontal engine is probably the most used at a high pressure in this country; its advantage is the facility with which it is put up, and its steady working; every part being firmly attached to a solid bed, requiring but little bracing to keep it in place. The disadvantage of a horizontal engine is the unequal wear of the cylinder, due to the gravity of the piston. The steeple or vertical engine has, like the beam engine, an upright cylinder, but is connected directly to the main shaft above or below. In all the above-named engines the cylinder is stationary, and the reciprocating motion is changed into rotary by means of a cross-head, slides, and connecting-rod; in the oscillating engine the cylinder vibrates upon trunions, placed sometimes at its centre, and sometimes at its end; thus allowing the piston to be coupled to the crank, and doing away with the cross-head and slides. The advantages of this engine are its reduced size and expense. In the horizontal and other engines the steam valve is moved by an eccentric, but in some oscillators the trunion box forms a self-working valve both for induction at the one side and eduction at the other. The disadvantages of an oscillator are the liability to overheat its trunions and the difficulty of keeping them tight. An oscillator costs less at the start, but requires more oil, and is of doubtful economy.

The change of the reciprocating into the rotary motion was a problem for many years, and the idea that there was a great loss of momentum in the constant stopping and starting of the piston at each end of the stroke induced many mechanics to study some method of obtaining a direct rotary motion, or, in other words, to produce a rotary piston. It was at once evident to the merest novice that a rotary engine would be in reality a rotary pump reversed, and consequently the rotary engines bear so strong a resemblance to the oldest rotary pump as to instantly strike the eye of any one who has seen the two. One of the most successful rotary engines of to-day is that of Holly, of Seneca Falls, New York, and this is only a modification of Murdoch's rotary

engine, which is, in turn, a perfect copy of an old pump taken from Serviere's collection. It may be thus described: two cog-wheels fitted accurately to each other are inclosed in a case; each cog is grooved and fitted with packing, bringing it into steam-tight contact with the circumference and sides of the case. The axles of the cog-wheels are continued through the sides of the case, and geared together at each end to prevent friction upon the centre cogs; now, if revolved, each cog will act as a piston, but as the cogs in contact in the centre lap each other, the piston surface at each extreme of the case will be just double that of the centre, and this surplus of force gives motion to the two axles. The pump of which this engine is a copy was invented as long ago as the sixteenth century.

A patent was obtained in England in 1825 by Mr. J. Eve, an American. Within a cylindrical case a hollow drum was so constructed as to fit closely to the case; floats, or pistons, were cast upon its periphery, and packed to fit the cylinder; on one side of the main cylinder was a small recess filled with a small drum, that revolved in contact with the main drum, this small drum having a segment removed to receive each piston as it passed, and having its diameter so proportioned to the main drum as to revolve once between the passage of each piston or float. Other rotary engines, on a plan analogous to the above, differing only in the manner of opening the valve, have been invented, and copied from the ancients, some of which are exceedingly complicated, but they have always been unsuccessful in practice, principally from the fact that it is exceedingly difficult to pack them. If they could overcome this fault without adding friction, the rotary engine would be very valuable on account of the small space it occupies.

The demand for stationary engines, from one horse power upward, during the last twenty-five years, has been so great that now almost any machine shop is prepared to build them, and of course, while such is the case, thousands of engines are annually built that would better bear the name of steam eaters than steam engines. In some of the small engines that flood the market, the first principles of steam are practically ignored, and there are at this moment running in the United States engines that consume more coal to do the work of ten horses than a properly-constructed one would use to do the work of twenty. As an instance of the truth of this statement, we will take the engines built by Messrs. Corliss & Nightengale, of Providence, over an engine that was working to good advantage in the James Mills, Newburyport, but was removed on the representation of the builders of the new machine, that they would take five times the saving of the first year's fuel as sole payment of their engine. The James Steam Mills contained 17,024 spindles, and, including the weaving and all the preparations for making sheeting and shirtings, required a hundred and ninety horse power; their engines were condensers; cylinders, twenty-four inches by four feet length of stroke. Ten thousand four hundred and eighty-three pounds of coal per day was the average amount used during five years previous to the contract for the new engines; this included the coal used for dressing, heating, and all other purposes for which steam is used in such an establishment. The new engines were high-pressure cylinders, eighteen inches by four feet stroke. By the terms of contract under which the change of engines was made, it was at the option of the company to pay for the new arrangement the sum of ten thousand five hundred dollars cash in lieu of the saving of coal; but the choice was to be made before the new engines were put in operation. In view of the favorable results obtained by the former engines, they decided to pay in the saving of fuel. The new engines were run one year from December 3d, 1855, and the average amount of coal used per day was found to be five thousand six hundred and ninety pounds. The coal being reckoned at six dollars per ton, Messrs. Corliss & Nightengale received nineteen thousand seven hundred and thirty-four dollars and twenty-two cents. Thus it will be seen that the builders received nearly double price for their engine, and yet it cost the owners of the mill nothing for a machine that was destined to be a source of great saving in their future expenses.

The singular character of Mr. Corliss' bargains attracted much attention to his engines, as they showed conclusively the advantages thereof over the old plans. The above experiment was a comparison between his engine and what had been considered a good machine; in the following, however, we see its great advantages over a more or-

dinary engine. In March, 1852, Mr. Corliss contracted with Crocker Brothers & Co., of Taunton, Massachusetts, to furnish them with an engine that would do the same work they were then doing with five tons of coal per day, and yet only consume two; agreeing to forfeit one dollar per pound, for every pound per day used above that amount. This contract was successfully filled without taking out the old boilers.

Mr. Corliss' engines possessed, as may be readily supposed, several important improvements, one of which was the manner by which its speed was regulated. Watt regulated by connecting the governor with the throttle-valve; Corliss used no throttle-valve, but connected the governor direct to the cut-off. This connection of the governor was not of itself the improvement of Mr. Corliss, as that had already been done by others; but it was the manner by which this connection was made, which was at once simple and efficacious, for which he deserves credit. The use of the throttle-valve was always attended with a wire-drawing of the steam. This wire-drawing is a reduction of the expansive force of the steam, and is always attended with more or less condensation; so that every form of cut-off, used with a throttle, is more or less imperfect. By thus dispensing with the throttle-valve altogether, and opening the steam-valve suddenly, the pressure of steam in the cylinder approximates very closely to the boiler pressure. The valves in the Corliss engine are circular; and by his automatic method of varying the point of cut-off, he gains a great advantage, as he cuts off suddenly without danger of slamming, as in the use of the puppet-valve.

We do not wish to be understood to say that the Corliss engines are the best in the market; they are among the best; and we have dwelt thus long on some of their merits in order to contrast them with others. When we add the fact that one-half of the stationary engines in the United States are run by boys or men not capable of managing a modern cooking-stove, the reader can realize to some extent the economy of cheap (?) engines and cheap (?) engineers. Steam is a good slave but a bad master; and the fearful loss of life in the United States during the past forty years, from the explosion of steam boilers, is mainly due to bad management. Boilers are in constant use all over the country, carrying a pressure double—nay, triple—that for which they were intended; the safety (?) valve weighted down by old pieces of iron, stones, etc., to such an extent that the *runner* no more knows what pressure he is using, than does the stranger who is passing his door. In thousands of cases the steam-gauge, which, at least, gives the pressure when in order, is not used, or never tested; and what was intended as a preventive, becomes, by a stoppage in the connecting pipe or a derangement of its machinery, a source of treacherous security. Many a man, on being asked why he does not use a steam-gauge, will reply that they are not reliable, or that the safety-valve is good enough; and yet that same man is perhaps employing an engineer that could not calculate, to save his life, the amount of pressure he was carrying, or, the size of his safety-valve being given, tell its area in square inches. "We can point out places where the engines, beautifully designed and executed in their details, are nothing but a mass of slime and grease from bed-plate to cylinder-head, the deposit of no one knows how many weeks of inattention and neglect, while a stolid *runner* sits calmly by, as though rather admiring the state of things than otherwise. When such is the case where every thing is visible, where is the necessity of looking among the usually unsearched portions of the machine for safety and economy."

A steam boiler blew up in Brooklyn a few months ago, and we went over to examine it; we were told the engineer had run an engine for some time. Whether this was true or not, the man was one who did not understand his business, as is sufficiently evident from the following reasons: his pump was small, but sufficiently large if in good order—which it certainly was not; we took out the piston with ease, and put it back again readily, although it was entirely covered with the coarse gravel and sand thrown about by the explosion. The safety-valve was held in its place by a rod passing through a plate; this rod, originally a good fit, was so firmly rusted in its place, that all the force we could exert on the end of the lever was not sufficient to move it. We unscrewed this plate, and it required two or three smart blows of the hammer to drive the rod out. In our opinion, it would have taken not less than twelve hundred pounds in the boiler to have started that valve, allowing that it had the weight upon it that we saw. The owner

stated that the valve always leaked more or less; but on looking at it we were convinced that if it rested upon its seat, it never could have leaked, as it was a ground joint and a good one. We consequently came to the conclusion that the valve was not held in its place by the weight on the lever, but simply by the rust on the valve-rod or stem, the weight at the end having nothing to do with it. The safety-valve was bolted on to the steam dome with four 5-8 bolts, and was evidently blown off at the same instant as the flue collapsed, as it was found in the shop near the engine, while the boiler was thrown at least seventy-five feet against a house.

We might name scores of other accidents resulting from similar causes, of which the above is a fair sample; but it is evident enough, from what we have already said, that there is a want in the community yet unfilled—one that should receive the careful attention of every public man. What we need is a law compelling the owners of steam boilers to have them inspected at least once a year, and properly provided with *safety*-valves and other trustworthy appliances; it also should be imperatively their duty to employ *engineers*, and not mere runners. A law framed upon the United States steamboat inspection plan would be of incalculable benefit to the owners themselves, as well as the community at large.

The gradual introduction of the stationary engine has been of infinite value to our country as it is, but if rendered safe as it might be, its value would be increased fourfold. It is now no longer necessary that the manufacturer should locate beside a waterfall, and transport his manufactured goods for miles to a market; he can establish himself beside the railroad, the steamboat, nay, in the city itself, where his customers dwell. Thus, the stationary engine tends to centralize manufactures, while the locomotive and steamboat lengthen the arms of trade.

The portable engine has lately come into general use, and, like the stationary, is made of various forms, in all of which it resembles the latter, with the exception of placing the engine directly upon, or against the boiler. These engines are used wherever it is necessary to do work sufficiently great to pay for them, but not for permanent business, such as pile driving, excavating, etc. Among the simplest of this class of engines, may be mentioned Reed's oscillator, and Hittinger, Cook & Co.'s. A portable engine manufactured at the Washington Iron Works, contains all the safety and economic appliances of the best stationary engines; a description of these portable engines will answer for this class of machines. The boiler is tubular, commonly called a locomotive boiler, and is mounted upon two large wheels at the fire-box end, and two small wheels at the smoke-box end, so fitted as to turn beneath the barrel. The steam dome is over the fire-box, and is fitted with safety-valve and steam gauge. The cylinder is fastened to a hollow frame that serves as a feed-water heater, and is placed very near the steam dome, thereby preventing radiation in the steam pipe. Upon the top of the steam chest is placed the governor. On the front of the boiler we find the smoke pipe, and, directly behind it, the main shaft and a pair of balance wheels. The next matter of interest is the arrangement of the main slide-valve of the engine, which is well known to cause much loss of power, in the ordinary construction, by the friction caused by the pressure of steam on its back. This is entirely relieved by a very simple method in this engine. The valve, which is an ordinary one, has a solid protection at each end, which rests on a roller. These rollers are made at first slightly too small, but the grinding away of the valve on its seat soon causes the projections to rest on the rollers, when all the sliding friction at once ceases, and the valve works free from friction except that caused by the stuffing-box around its rod. It is evident that this arrangement will not readily get out of order, for when the rollers wear, it brings the valve on the seat, which at once begins to wear, and the pressure once more is brought on the rollers; hence, it is self-adjusting. The rollers being removed, reduces it to the usual slide-valve.

The force pump has been a fruitful source of trouble to all those who have ever had charge of a small steam engine having a quick motion; indeed, it frequently gives trouble in larger engines, from the accumulation of air in the chamber, which prevents its suction. It is usual to have attached to the lower part of the pump, or valve chamber, a small air-cock, and, when the pump is to start, the attendant places his finger on its extremity as soon as the plunger reaches the bottom of the pump, thus expelling the air; then, on the rise of the plunger, a vacuum is

formed, and the pump fills with water; the cock is then closed, and the pump left to itself. As soon, however, as air collects from any defect of packing, or otherwise, the pump ceases to work, and has to be again started as before. This difficulty is entirely got rid of by the simple contrivance of an air-trap, whose valve, opening outward at each downward stroke of the pump, allows the air to escape, accompanied with a little water, and closes by the atmospheric pressure as the plunger rises.

Within the last five years, the labor of loading and unloading vessels at our wharves has been performed by hoisting engines. These are all run at high pressure, and do the work with economy and dispatch. One of the best of these machines is made at the shop of Hittinger & Cook. The steamer Matanzas carries one on board, to use at the other end of the route. The hoisting so much resembles the portable engine, as not to require especial explanation.

In most of the steam sawmills in the United States, the fuel consists of the sawdust made at the mills, and thus the cost of running is greatly reduced; in other engines, coal is almost exclusively used. In fact, the enormous amount of wood consumed by steam engines throughout the United States, has so called the attention of mechanics to coal-burning engines, that it is not probable we shall use wood as fuel many years longer. One of the greatest fields for economy in the use of steam, now open, is the waste of combustible gases by the chimney, commonly spoken of under the term *smoke*, but often consisting of the best part of the fuel, unconsumed from the lack of oxygen, and, in some cases, lack of caloric. Tubes, to conduct atmospheric air to the surface of the fire, have been in use some time, also the perforation of the fire door; but the tubes being exposed to an intense heat, soon become of no value, and the openings at the door and sides of the fire-box only partially supply the oxygen. A Mr. Pierce, of Troy, has patented a plan for surrounding the air tubes with water, thus protecting a passage direct to the middle of the fire; we have not seen this plan tried, but think it would be a source of economy.

Stationary engines being the most plenty, it is upon them that are tried nearly all the new experiments. At the present time, the use of super-heated steam is attracting a great deal of attention. In order to understand this subject, it is necessary that we should look closely into the nature of steam itself. It would defeat the purpose of this article if we were to go into a lengthy argument upon the relative merits of the various theories that have been advanced by scientific men upon steam, and, consequently, we shall merely give our own opinions upon the subject—opinions to which we have arrived by careful study and experience, it being understood that the laws of steam are at best comparatively unknown. The analyzation of simple steam is yet to be made; we will, however, call it water converted into an aëriform state by the electrization of its particles by calòric. Simple steam does not, however, in the present construction of boilers, come into use as a motor, from the following reason: steam has the same affinity for liquids that all fluids have, forming an electro-magnetic combination to which there is no barrier; it will then absorb and hold in suspension particles of water whenever in direct contact therewith, and, consequently, all steam formed in the boiler will hold in suspension a portion of water, and become, in lieu of simple, surcharged steam. Thus, steam at 20 lbs. to the square inch holds in suspension nearly double its weight of water. What is the effect of this? First, the water thus carried off in suspension is at the maximum temperature, or equal to that of the steam containing it, and the invested heat of this water is not only wasted to a great extent, but these water particles become a very serious tax upon the real steam with which they are admixed, as follows: having been heated under the maximum pressure of the steam with which they are incorporated, they have a corresponding temperature, and as the latter, the steam, expands in the steam pipes, on its way to the cylinder, and in the cylinder itself, the pressure becoming correspondingly less, these particles flash partially into steam, but not containing the total amount of heat necessary to their constitution as elastic vapor, they absorb into the "latent" form a quota of heat from the surrounding particles of true steam, thus condensing them; for steam, be it remembered, can part with no portion of its legitimate heat without condensation (unless it be super-heat, of which presently), it being understood that the absorption of sensible heat (temperature) into the "latent" form, and which is the exact measure of the force exerted by steam under all circum-

stances, whether usefully realized or not, is not here meant as a loss of heat. That there is a loss by direct condensation because of the presence and action of these water particles as explained, may seem to some at the first glance a paradox, but there is in the case of steam, and between the particles of all matter, a certain impetus and momentum in the transference of that unknown something, which is their "*vis viva*," or cause of elasticity. The electrician knows this well; *vide* the "lateral discharge" and return stroke. Again, for more common place example, fasten by one extremity a straight spring, bend it, release it, it flies back, not to its original position of rest or neutral point, but far beyond, though finally it will settle there. And so it might be held that the particles of steam would make "reprisal," so to speak, of the heat stolen by the particles of water flashing into steam, as set forth; and so they do, but meantime the piston is moving on, and this heat, the source of the elastic force of the steam, cannot, it will be evident, be acting efficiently in two or more directions at the same time; but this is not all, the more watery particles in the steam, the more heat wasted by conduction to, and radiation from, the steam pipes, cylinders, etc.

Water is classed as a non-conductor of heat to a high degree, but it is a medium radiator, and it vastly exceeds steam and other aëriform fluids in both these respects. This, to a great extent, accounts for the sudden falling off of power during "priming," so well known. But there is still another, as it were, negative loss due to this water carried off in the steam, because, by its minute subdivision, it exposes an immense surface to heat, particularly radiated heat, that might be brought to act upon it, and thus quickly transform it into perfect steam, much augmenting the volume of the whole, and being generated at less cost than the first portion which held it in suspension; and it is through the avoidance of the evils before mentioned as due to these water particles, and the gain produced by their conversion into elastic steam, that so much economy is found in the use of super-heated steam, which is steam that has received an excess of heat (temperature) beyond that normally due to its pressure when in direct contact with the water from whence it emanated. The system, however, is fallacious, because pure steam, and all other known aëriform fluids, expand only about 1-540th part of their volume, at the ordinary atmospheric temperature, for each degree of Fah. additional forced upon them. Pure steam thus, say at twenty pounds to the square inch, would require to be elevated to a temperature of about eight hundred Fahrenheit to double its volume if under a constant pressure, or to double its pressure if under a constant volume (the quantity of heat being, however, very different in the two cases); whereas the mere added temperature in this case would correspond to that of simple steam at a pressure of about seven hundred and fifty pounds to the square inch, not to mention that such, and far less temperatures, would destroy all packings, prevent lubrication, cause "cutting," warp valves, etc. There are other practical defects. Although there is no difficulty in super-heating the steam to any desired extent according to the size of the super-heating vessel and the part of the smoke or fire space in which it may be located, yet it is very difficult, if not impracticable, to maintain a proper average under the influence of fluctuating fires—at one time in full glow, at another freshly trimmed, and an uneven draft, damp or dry, weak or strong; the engine at one time under full motion, and a rapid flow of steam passing through the super-heater, and at another time the engine stopped, and there being little or no flow of moist steam through it to protect it from being overheated and "burnt out," or rendered brittle and insecure. Hence, if super-heating be attempted at all, it should be to the minimum degree, and not with the expectation of an important access of power that no degree will afford, but only to an extent sufficient to supply radiation from the various parts of the engine, etc., during the travel and action of the steam, thus preventing its condensation, which, to a given extent, involves not only that much immediate loss, but the more important coactive evils due to the presence of watery particles. The great and main object, then, is accomplished by the production and use of simple (dry) steam; any modicum of water present possessing but the negative advantage of supplying lubrication, and any "super" heat, that of supplying radiation.

We have dwelt at some length upon the laws of steam, but at best we can do but little justice to the subject, and, as we have already said, this article is intended mainly as a statement of the effects rather than the

causes, still we could not refrain from touching upon a subject that has already and is destined still to attract so much attention as this.

We cannot leave this branch of the subject without alluding to the new pumping engine lately erected at the Brooklyn Water Works. The impression is still generally prevalent that gravitation supplies of water for cities are cheaper and better in all cases where it is even possible to have them. It is plain, however, from numerous results throughout Europe and America, that the annual cost represented by the interest on the capital expended for gravitation supplies, except in special instances, far exceeds the annual cost of interest and maintenance incurred by properly arranged steam supplies, and that the quality of the water obtained is generally superior. In this respect, the contrast between New York and Brooklyn, which cannot be detailed here, is conclusive. This engine was built at Hartford, Conn., by Messrs. Woodruff & Beach, William Wright, Esq., being their superintending engineer. It is a double-acting Cornish engine, with all the peculiarities of the single-acting English engine, very much modified and improved. It has three return drop-flue boilers, thirty feet long, eight feet diameter, using about fifteen tons of coal per day. The engine has a cylinder of ninety inches bore and ten feet stroke, working a lifting pump at each end of the beam, of thirty-six inches bore and ten feet stroke. The lower pump under the cylinder works through it, and each is provided with an annular barrel, fifty-four inches diameter, with double-beat covers. The working buckets have double-beat valves. In smoothness of action, light friction, and pumping power, this engine takes the first rank among the pumping machinery of the world. It is more powerful by sixteen per cent. than the celebrated Leeghwater engine at work in the Harlem Meer. This result is highly creditable to Messrs. McElroy & Wright, under whose careful study and mechanical skill its several improvements were jointly developed.

The contract required the engine to lift six hundred thousand pounds of water, one foot with one pound of coal, with a delivery of ten million gallons in twenty-four hours; and to be further capable of delivering ten million gallons in sixteen hours. But this engine has done even better than this—14,500,000 gallons being its ordinary work. Although the most powerful, this engine is not the largest in the world, the Leeghwater engine bearing the palm in that respect. The Cornish engines, of which this is in most respects a type, are generally favorites among engineers. This system rejects the use of cranks and fly-wheels, gearing, or any other absorbents of power, and independent regulators of action—three essential elements of economy. The abundant records on file of the actual results in practice, go to show conclusively, that in the facility for carrying high steam, for great expansion, and in lightness of friction, the Cornish engines have the precedence of all others. No engines carry higher boiler pressure in pumping—a feature in itself of vital importance to economy; no engines habitually work under greater expansion; and it is impossible to improve on their simplicity of motion in the working parts. These are three conclusive distinctions; and the results obtained in the Brooklyn engine, which belongs to this school, are remarkable. Here is the most powerful pumping engine on the globe, with a frictional loss between the cylinder and pumps of only seven and a half per cent. Here is an engine which has doubled its boiler pressure by the simple addition of a few tons of counter-weight to its inertia, increasing its duty thirty-three per cent., and which only requires a greater addition of weight to carry its steam gauge, its expansion, and its duty, to the highest range of the European school.

Thus it will be seen that the results obtained with this engine on so magnificent a scale, have a very important bearing on two prominent engineering questions. First, in demonstrating the economy and value of a steam pumping supply; and second, in sustaining the Cornish school of practice in the construction of pumping engines. And more than this, the Brooklyn pumping engine has demonstrated that, however good the original Cornish engines may be, American mechanics can produce as good, if not better, at home.

CHAPTER V.

STEAM PUMPS.

The great desideratum in a machine for extinguishing fires, is the rapidity with which

it can be set to work, and next to this the quantity of water it will throw to a given height or distance. The machines that best filled these conditions were doubtless the American hand fire engines; but steam has now turned fireman, and in the contest between his iron arms and human muscle, we can readily determine the result. At first, time was the all-important item; all were ready to acknowledge that after the fire had attained full headway, the untiring efforts of steam were all-powerful, but as the majority of our fires were nipped in the bud by the rapidity with which the hand engines were brought to bear, it was not believed that steam would ever become economical, and rarely efficacious. An engine was constructed for the insurance companies of New York some twenty years since, but abandoned as too expensive; it was located in a house containing a boiler, wherein steam was constantly kept up at a low pressure, and so arranged as to discharge its water into the engine on an alarm of fire being given; beneath the boiler of the engine, shavings and light fuel were kept constantly laid, so that by the time the machine reached the fire it would have steam up and be ready for use. This was planned by Ericsson, who also planned the Braithwaites engine, used in England. The latter had two cylinders of about six inches in diameter, one for steam and the other as a pump; they were placed horizontally. This engine would deliver nine thousand gallons of water per hour to the height of ninety feet. The time consumed in getting to work from cold water was eighteen minutes. An engine built for the Prussian government in 1832 had two steam cylinders of twelve inches in diameter, with fourteen inch stroke, and two pumping cylinders of ten inches diameter. With a steam pressure of seventy pounds per square inch, this engine threw an inch and one quarter stream one hundred and twenty feet perpendicular; and an average duty was called ninety tons per hour. She consumed three bushels of coke per hour.

Such were the first steam fire engines. Experiments were frequently tried in the United States, but the whole subject remained in doubt until the year 1852, when the first public trial was made in Cincinnati. A steam generator, or boiler, which had been made for the purpose, was placed in connection with a steam cylinder and the pump of a fire engine belonging to the city, the whole mounted on suitable wheels and frame. A committee of the city council witnessed the experiment. From their report it appears that steam was raised from cold water, the engine started, and water discharged from the nozzle to the distance of one hundred and thirty feet, through three hundred and fifty feet of hose, in four minutes and ten seconds from the time that smoke was seen to issue from the chimney. The demonstration was convincing, and did convince. The city council contracted for a steam engine to be built on the same plan, and this engine, when completed, was placed in service under the charge of a company organized and put under pay by the city. Thus the first paid fire company, to operate with the untiring energy of steam, was brought into existence—the first of the kind in any age or country. Steam, whose resistless power had been so extensively used in the fabrication, development, and transportation of property, was at last compelled to aid in its preservation from fire. Its superiority over muscular power, acknowledged for other purposes so numerous, was to be asserted against conflagration; and a city not a century old, west of the Alleghanies, attracts the applause of intelligent men everywhere, and the pride of western men, as the scene of this achievement.

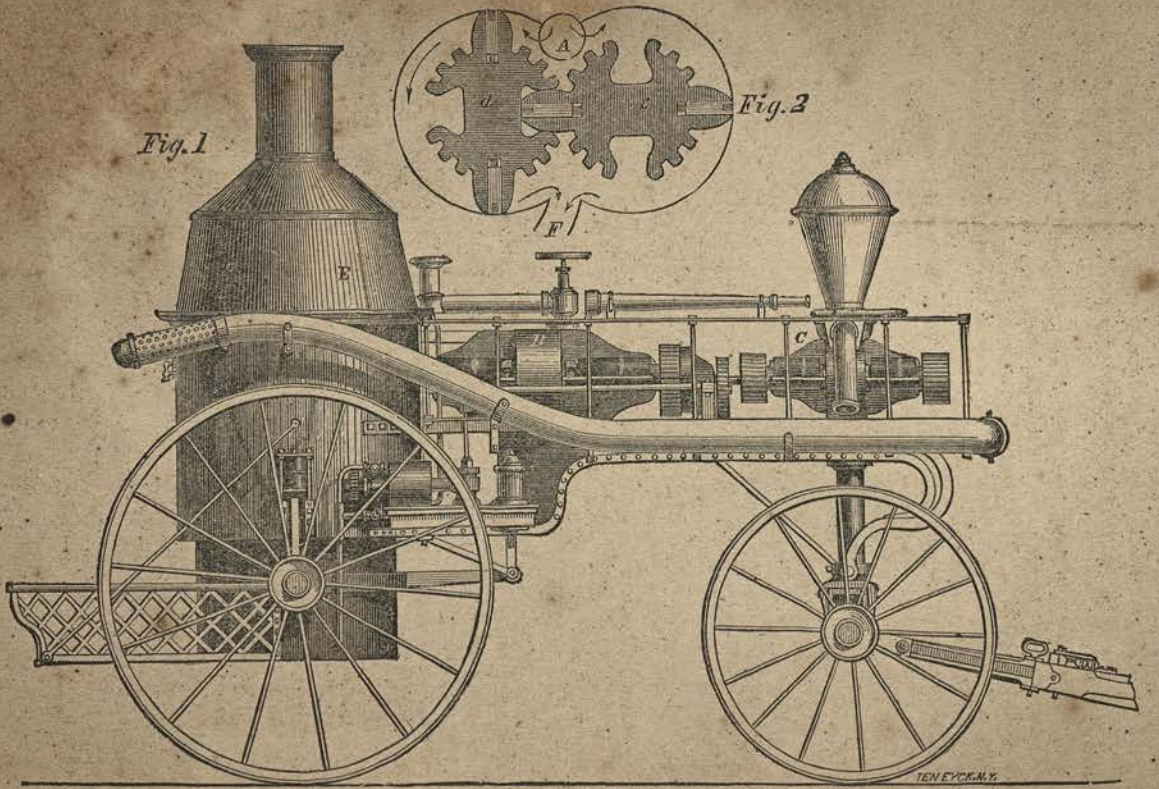
After this successful experiment and the organization of the paid department, Miles Greenwood was appointed chief engineer, and it is to his energy and perseverance that we owe the success of the steam fire engine. These steamers were constructed by Messrs. A. & B. Latta; the first in service was called the "Uncle Joe Ross." The circulation in the boiler is kept up by pumping, and thus steam is generated in a very short space of time; it is not, however, unattended with danger. After the success of Latta's engines, several manufacturers went into the business. Reaney & Neafy, of Philadelphia; Lee & Larned, of New York; Silsby & Mynderse, of Seneca Falls; the Amoskeag Manufacturing Company; the Boston Locomotive Works, and several others. Reaney & Neafy used what is commonly called the locomotive boiler; their engines gave good satisfaction, and at a trial in Boston, in 1858, they received the prize over three competitors. Of the Lee & Larned self-propeller we have already spoken (J. C. Cary and J. G. Storm); they, however, build a light hand engine, and have heretofore furnished

all the steamers for New York city. Their boiler is of the upright annular form, Cary's patent, and their pump is rotary, patented by the same man.

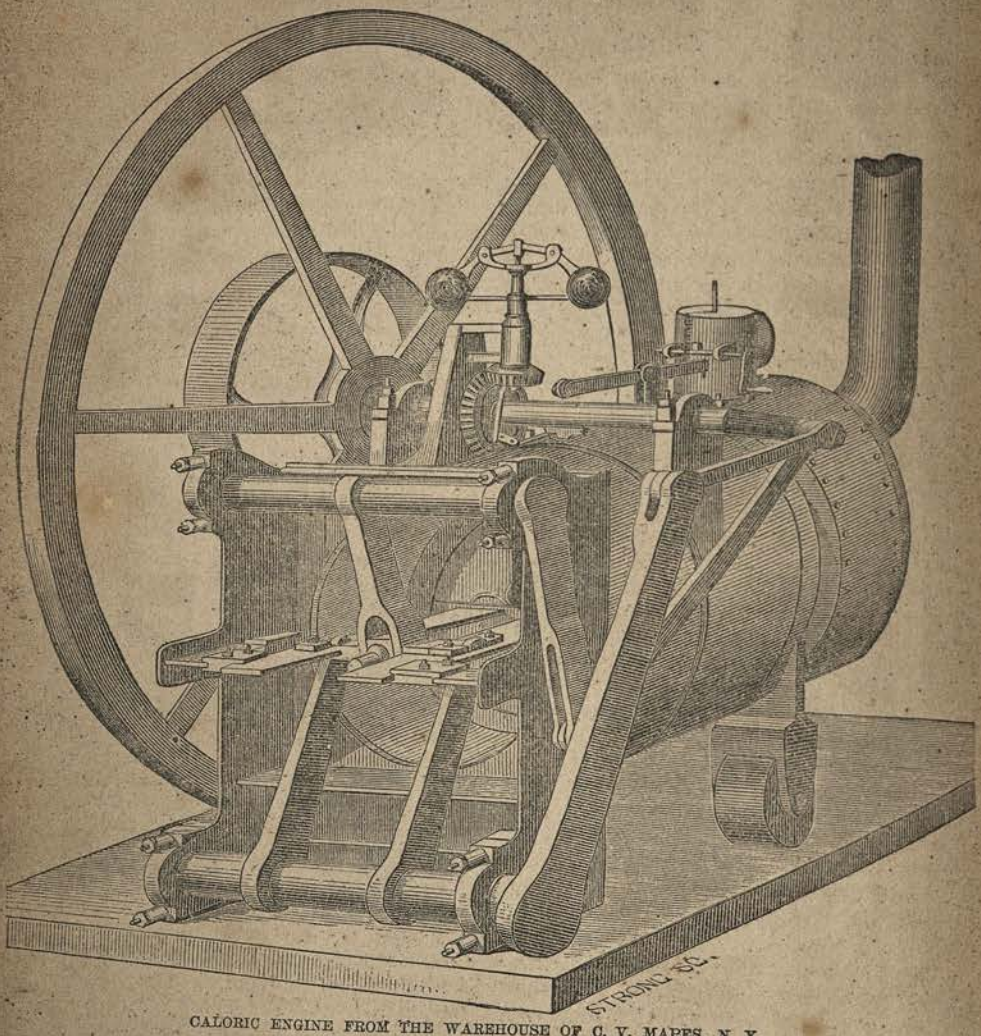
The Amoskeag steam fire engine has some peculiar features, among which may be named the vertical cylinders and pumps, by the use of which they avoid to a certain extent the shaking that is so objectionable in some of the other machines; also the arrangement of their gauge cocks so as to cover the whole side of the boiler and show at once the height of the water, which is used in this boiler at a very low point in commencing, thereby enabling them to get up steam very rapidly. At a trial in New York in September, 1860, they obtained a working pressure from water at 90° Fahrenheit in three and one-half minutes. These machines have thrown a one and three-quarter inch stream two hundred and twenty-five feet high. They weigh about six thousand pounds, and are intended to be drawn by horses. The Selsby & Mynderse engines are entirely different from any other in their construction and operation; the engine and pump are both rotary, and are built after Holly's patent; we have already spoken of this engine under the head of Stationaries. The weight of these machines is as follows: to be drawn by men—four thousand five hundred pounds light; five thousand one hundred pounds with fuel, water, suction hose etc., all ready for service; this size is warranted to force a one and one-eighth inch stream two hundred and twenty-five feet, or two, one hundred and eighty feet, with a steam pressure of from forty to sixty pounds. To be drawn by horses—five thousand six hundred pounds light; six thousand three hundred ready for service; forces a one and one half inch stream two hundred and twenty feet, or two one inch streams the same distance. These machines will get to work in from four to six minutes. The best work ever done by this style engine was in Providence, R. I., where an engine weighing six thousand two hundred pounds, threw a one and a quarter inch stream two hundred and fifty-five feet horizontal. One great advantage of the Holly pump is that it runs steadily, no chocking being required to keep the engine in place while on duty, as is the case with all engines having reciprocating pumps.

Other steam fire engines, for the use of factories and large buildings, not intended to be transported, have been in existence for a greater length of time; these machines are also used as auxiliary pumps for supplying water to the boilers of larger engines, and are generally called "doctors," or "donkeys." Among the best of these are Worthington's and Woodward's steam pumps. The importance of an auxiliary pump, in all cases, cannot be too much dwelt upon. If the pump be attached to the main engine, it is evident that on the lack of water in the boiler, the main engine must be started. This is not always possible. A sudden break down in a mill would necessitate the uncoupling of the shafting before the boiler could be fed. The lack of water at a station when waiting for a train, obliges the engineer to run back and forth upon the road; and if a boat stops at a wharf, or is enveloped in a fog, the power that works the pump ceases with the engine. But how is it when the engine itself breaks down, or the locomotive is embedded in a snow bank, as is sometimes the case? Why, the engineer must draw his fires to avoid ruining his boiler. Bearing these facts in mind, the advantages of an extra steam pump are obvious.

The Worthington pump is exceedingly simple in its construction; as the reciprocating motion in the steam and water cylinder is the exact motion required, the cross-head, slides, and balance wheel are dispensed with as useless. In the Woodward, however, the connecting-rod, crank, and wheel are retained to give motion to the valve, which in Worthington's pump is moved by an arm attached to the piston rod. Both of these pumps are favorites, and it is difficult to judge which is best. The importance of these steam pumps as auxiliaries is not, however, their only advantage. On board of our steamboats, such pumps as are provided in case of fire are often rendered of no avail by the necessity that exists of stopping the progress of the boat in order to check the current of air, which otherwise would increase the flames. And let a fire engine be kept on board for the single purpose of extinguishing fires if they happen—does not our common experience teach us that in so imminent a danger, when all are seeking personal safety, and unwilling to await the issue of a doubtful effort for the general preservation, such a machine will be found a very questionable dependence? Will they not be difficult of access at the moment, or out of order, from rust or disuse, when most



SILSBY'S FIRE ENGINE, HOLLY'S PATENT PUMP.—CHAS. W. COPELAND, AGENT, 122 BROADWAY, N. Y.



CALORIC ENGINE FROM THE WAREHOUSE OF C. V. MAPES, N. Y.

needed? And does the confusion, which is always attendant upon such an occasion, allow of reasonable hope that they will be found and repaired in time to be of use?

These are questions which can, perhaps, be best answered by those who have witnessed the scene of a steamboat on fire. But with the "donkey" engine, the case is quite different; being constantly in use, it is always in order, and in case of fire it can at once be brought to bear upon the flames; it is also always at hand in case of a leak that overpowers all other available pumps; and, in fact, its advantages are so great that no boat, locomotive, or stationary engine should ever be run without one. For large pumping operations, also, it is believed that the Worthington pump has many advantages. The power is direct, all the motions are rectilinear, the friction is not great, nor is the wear excessive. A steam and a pump cylinder attached to one frame, with two pistons, two valves, and two rods, comprise the whole machine. The economy of the donkey engines is obvious where steam is only employed for boiling, or for warming buildings, and where the large and costly engines usually provided in such cases, are used solely for driving a pump to supply the boiler. The steam used to drive it, whether of high or low pressure, is, of course, just adequate to the required work of forcing water into the boiler against the same pressure.

The Worthington pumps are made of a great variety of sizes, from the miniature ones used as feeders on the Lee & Larned fire engines, up to the huge pumping engines for water works. The only fault we have ever heard found with them is the trouble of starting; this cannot, however, be very great, inasmuch as a pump, to be efficacious as a feeder for a fire engine, must be readily started or it would be almost valueless. The Woodward pump has much more brass used in its construction than any other, and is therefore not so liable to rust. The Holly pump has been constructed as an auxiliary engine, and, in fact, on some of their larger machines a small one is used as a feeder; it occupies but very little space, and is well spoken of by those who have used it. A pumping engine manufactured by Messrs. Carpenter & Plass, of New York, has been lately introduced, and has the advantage over the Worthington of starting at once on opening the throttle; it being fully as simple. Other pumps of this class are manufactured all over the country, but none are so well known as the ones we have named. On some of the western steamboats they use small engines of the ordinary construction attached to the common force pump, but in no case are they so compact, easy of repair, or durable as the above-named steam pumps.

CHAPTER VI.

MISCELLANEOUS.

In the former chapters we have set forth the various forms in which the adaptation of steam is most familiar to the community; in all of which steam was used as a motor only; and before dismissing this portion of the labor of steam, we will allude briefly to some other machines, destined, perhaps, to effect as great a revolution in other branches of industry, as the locomotive and steamboat have in transportation, and the stationary in manufactures. Agriculture—that wide extended base, upon which we have built up this great fabric of commerce, manufacture, and trade—has been the last to experience a direct benefit from steam. The farmer is pre-eminently conservative, to which the monotonous routine of his business predisposes him; but the course of the giant worker, steam, is irresistible, and he, too, at last accepts its aid. For some time past the portable engine has been introduced to assist the farmer in the laborious duties of his calling, and soon will the iron horse be chained to the plough, swing the gleaming scythe, sow, reap, thresh, and winnow, while the husbandman will guide and direct the iron arms which do his bidding uncomplainingly. Already has the shriek of our new friend been heard upon the western prairie field, and the smooth-turned furrow attested his strength, but as yet he takes not kindly to his new-found toil, and the brains of a score of inventors are at work to teach him this new duty. "God speed the (steam) plough," say we.

But this great problem, the education of steam to its new duty, presents many difficulties. There are three kinds of engines—the locomotive, the portable, and the stationary—capable of being employed in steam cultivation; and there may, consequently, be three kinds of steam cultivators invented, each characterized, in its general features, by the kind of engine employed; though

under each class there may be many modifications of parts, rendering the members of the same class as widely different as those of different classes. These varieties would be determined by the structure, form, or size of the engine itself; by the mode of conveying the power to the tools or implements with which it works; and by the nature of the tools or implements it uses. First, then, the locomotive steam plough; this may be employed to draw a gang of ploughs after it, or by a series of knives, cutters, or some form of cultivator, turn up the ground as it passes. The moving of this great mass, however, consumes much of the power, and the difficulty presented by steep grades is very great. The mere sinking of the wheels may be obviated, as it is in the Fawkes engine, by broad wheels, but even these sometimes slip. In Boydell's engines the machine lays and takes up alternately a succession of rails, upon which to roll. Hacket proposed to lay a temporary rail, but found it very expensive. The use of legs, or pushers, has also been tried in England, but was not successful.

The portable engine has been used in several ways. As a cultivator it was mounted upon a wagon drawn by horses. As a plough it has been placed by the side of the field, working a gang of ploughs by chains and cables; and after finishing one field, easily transported to another; this was called in England the Wolston system, but is at best very slow. The portable engine has also been used with anchors, and to warp, or draw itself along by stretched ropes. Each of the above methods of employing steam has its peculiar difficulties and defects. In the first one, two horses would be required to draw an engine of the lightest construction over safe ground, and up and down hill; and the advantage of the machine over animal power alone, would be only the difference between its work and what the team would do without it. The inventor, however, calculates that with an engine of two horse power, and of suitable construction, working a revolving axle, carrying tires armed with a kind of short spade toward their points, he can do the work of twelve horses, giving the work of ten horses and their attendants for the cost of feed and repairs, pay of attendants, interest of capital, etc. In the Wolston method the mode of transferring the power is indirect, the apparatus is complex and clumsy, and its success, thus far, has been but small. In the third plan, or that of the warping engine, the inventor asserts that he requires an engine of less than one-half the weight, power, or cost of any locomotive; that he avoids all indirect strain upon his cable, by getting the engine to warp itself from one side of the field to the other, by means of a single rope passing a couple of times round a drum; that the anchor at either side can be removed and passed forward six or eight feet, by one man, while the engine is travelling across the field; that, when using rotary cultivators, he has but little strain upon his cable; and, lastly, that when he is drawing ploughs, etc., he has the whole traction power of his cable to prevent his being brought to a stand by his wheels slipping. The stationary engine has been used to some extent, but we do not think it has sufficient merit ever to come into practical use.

As a motor for a dredging machine for deepening our rivers and harbors, steam has been in use since the time of Oliver Evans; and as an excavator it has long ago distanced human opposition. The millions of dollars that are annually expended in excavating earth, have attracted the attention of inventors to devise modes of aiding the operation by machinery, and large and costly machines have been made for this purpose in certain situations, especially in deep cuts of soft sand, which work well, and perform the labor of many men. Among many others, Messrs. Goodale & Marsh patented last year a machine that not only acts as an excavator, but transports the earth to the desired place of deposit, it being intended to work in ground free from large stones, or nearly so, and where the hills are not too steep for the ascent and descent of a locomotive running on broad wheels on the ground. This machine will prove particularly useful in the west.

Steam has always benefited the farmer by bringing him nearer to a market, and inasmuch as it reduces the expense thereof, it necessarily adds to his profit. The handling of the large amount of grain that annually passes through the large warehouses of our western cities, is of itself no small item, and here, too, steam lends its assistance, being adapted to the large steam elevators of Chicago. It has benefited the blacksmith indirectly by blowing his furnaces and driving the trip hammers, and directly

within the past ten years in the immense steam hammers, where it is so much under control as to give a blow of several tons weight, or crack a walnut in the attendant's fingers without harming him. For this advantage we were at first indebted to England; but we are improving upon the model, and steam hammers will soon come into general use, of American manufacture alone. An enormous steam hammer on Naylor's principle was lately sent to Australia. The hammer is not only lifted by the pressure of steam from below, but the gravity of the falling hammer is assisted by the pressure of steam from above. The work is finished at one heat, saving both the fuel and time of second heats, also consequent deterioration and waste of iron. The effect of the blow of this hammer will be equal to the momentum acquired by sixteen tons making forty blows per minute. The hammer can be made to work double or single, acting instantaneously; and by the adjusting valve gearing, the length of stroke and force of blow can be changed instantly. In all gravity hammers the effect of the blow is dependent on the weight of the hammer, multiplied by the height of its fall, and consequently, the greater the distance it falls, the greater the force of the blow, and the slower is the speed of working. In the double-action hammer, thrice the force of blow can be given at double the speed. The principal dimensions and weights are: timber foundation, twenty-six feet by twenty-four feet six inches, depth, thirteen feet; cast iron anvil block; base eleven feet six inches by nine feet six inches, thirty tons weight; base plate to receive standards, nineteen feet six inches by fifteen feet six inches, fourteen tons weight; standards, ten feet six inches apart, weight fifteen tons; height from ground to top of steam cylinder, twenty-one feet six inches; weight of all, about seventy-five tons. Steam to work this hammer is generated from the furnace in which the work to be operated upon is heated, the boiler forming the chimney, and the heat passing up four flues in the same, thus economizing fuel and avoiding the expense of a brick chimney. The boiler is six feet six inches in diameter, and thirty feet long; weight, fifteen tons. The weight of the whole apparatus, including boiler and mountings, is about one hundred tons. This apparatus was constructed in England.

Steam has also been applied to cranes with great success. One of Morrison's steam cranes was recently loaded with forty-five cwt., the steam cut off from the boiler, and the load left to hang from the crane by the power of the steam already in the crane cylinder. After hanging for half an hour, the weight had descended only four inches. Many other applications of steam as a motor might be enumerated if space would allow, but we must now turn to the multifarious duties of steam in the useful arts. One of the most important of its applications is its use as a vehicle for transferring and uniformly distributing heat. Its large capacity for caloric gives it great efficiency for this purpose, as it holds and will communicate as much heat as a mass of red-hot iron, and will transmit this heat to a great distance, which iron will not do, for the heat will remain latent until the steam reaches its destination and becomes condensed. In order to apply steam to the warming of buildings, it is only necessary to use a close boiler, from the top of which a steam pipe can be carried to the top of the building; the boiler being placed as low as possible. This steam pipe is at the top connected with a series of larger ones, placed with a slight inclination near the floor of each room, connected each with the one above it, at its highest end; thus giving facility to the descent of the condensed water, which is so directed as to re-enter the boiler near the bottom. By such an arrangement, properly constructed, the entire caloric produced by the furnace will be distributed over the building. The small, or steam pipe should be made quite strong, and should have at least an area of one square inch for every six gallons of water evaporated per hour in the boiler. It will require occasionally an addition of water to supply accidental waste, and a ball-cock connected to the feed pipe would be useful; but by all means have a safety-valve upon the boiler.

The extent to which buildings are now heated by steam in this country is very great, and since the introduction of Gold's apparatus, and some others whose names we do not remember, steam heaters have been added with great advantage to private dwellings. They are certainly much more healthy than hot air, and, properly arranged and managed, need not be more expensive. The pressure is merely nominal, and therefore not a source of danger; the only disadvantage, that of leakage, is no greater than in the use of gas pipes. For large factories, steam as a

heater is invaluable; and for warming hothouses, nothing can supply its place. It gives an equal heat, and is devoid of that dryness so injurious to plants. To warm a greenhouse by steam, there is required the boiler of a steam engine, reckoned at one horse power for every thousand feet of glass. It is advisable, when heating a hothouse by steam, to surround the pipes with stones; these stones absorb the heat, and if from carelessness or inattention the steam goes down, they will continue to radiate heat for some time, thus preventing the sudden cooling of the place.

It is sometimes necessary to boil liquids in vessels of wood, as in brewing, etc., and to use heat in evaporating thickened liquids, strong solutions, etc., where the direct application of fire would be destructive; there, also, we see the utility of steam. The common manner of making glue is an instance of this; elevate the bottom of the glue-pot and cover the receptacle for boiling water, and you have at once a steam oven. This plan has been extensively used in making salt. Or, introduce a pipe in the form of the worm of a still into the vat containing the solution, and allow the steam to pass through the pipe. The steam pipe can then be of iron, copper, lead, or tin, as the nature of the solution may require; copper is in all cases the best where it can be used. Another process of a similar nature was invented by Mr. Goodlet, of Leith; it consists of pumping the solution through a spiral pipe passing through the boiler, thus bringing the solution to the steam, instead of the steam to the solution. Steam kilns for drying grain have also been used upon the same principle. Dry houses, for lumber to be used in the pattern room, are added to our machine shops. The process of drying printed cloths and fabrics of various kinds, also the warp after it is sized, is in use in all our principal manufactories, and adds materially to the economy and expedition of their production. The process of drying cloths illustrates this. Steam is conducted through the axis of a cylinder, which is revolved by suitable machinery; the cloth is then made to pass over it in contact with its periphery; if necessary, several cylinders are placed in a line, and the cloth passes over the first, under the second, and so on. Paper is thus dried: the wet pulp laid out on the web of wire cloth is gradually strained as it approaches the cylinders, around which it winds, until it comes off dry and ready for cutting; this operation is singularly interesting.

Cooking by steam was the invention of Denis Papin, of France, as long ago as 1680; the most important of whose experiments were the extraction of gelatine from bones, and the manufacture of essence of meat, soups, etc., suitable for long sea voyages. From a work published by him in 1681, we extract the following: "I took," says he, "beef bones that had never been boiled, but kept dry a long time, and of the hardest part of the leg; these being put into a little glass pot with water, I included in the engine, together with another little glass pot full with bones and water too, but in this the bones were ribs, and had been boiled already. Having prest the fire till the drop of water would dry away in three seconds, and had ten pressures, I took off the fire, and the vessels being cooled, I found very good jelly in both my pots; but that which had been made out of ribs had a kind of a reddish color, which I believe might proceed from the medullary part; the other jelly was without color, like hartshorn jelly; and I may say, that having seasoned it with sugar and juice of lemon, I did eat it with as much pleasure, and found it as stomachical, as if it had been jelly of hartshorn." Mutton bones are better than beef bones; and he infers, first, that one pound of beef bones affords about two pounds of jelly; second, that it is the cement (gelatine) that unites the parts of the bones, which is dissolved in the water to make it a jelly, since after that, the bones remain brittle; third, that few glutinous parts are sufficient to congeal much water, "for I found that when the jelly was dried, I had very little glue (gluten?) remaining; fourth, I used it to glue a broken glass, which did since that time hold very well, and even be washed as well as if it had never been broken; fifth, it is heavier than water, and sinks to the bottom; sixth, hartshorn produces five times its weight of jelly.

"From all these experiments, I think it very likely that if people would be persuaded to lay by bones, gristles, tendons, feet, and other parts of animals that are solid enough to be kept without salt, whereof people throw away more than would be necessary to supply all the ships that England has at sea, the ships might always be furnished with better and cheaper victuals than they use to have. And I may say that such

victuals would take up less room, too, because they have a great deal more nourishment in them in proportion to their weight. They would also be more wholesome than salt meat. Vegetables, such as dried peas, may also be cooked by the steam of salt water without becoming salt."

We have already mentioned that Denis Papin invented the safety-valve; it was in the construction of this digester that he used it; he thus speaks of it: "To know the quantity of the inward pressure, you must have a little pipe open at both ends, this being soldered to a hole in the cover, is to be stopped at the top with a little valve, exactly ground to it. This must be kept down with an iron rod, one end of which must be put into an iron staple, fastened to the bar, and the other end kept down by a weight, to be hung upon it nearer or further from the valve, according as you would keep it less or more strong, after the manner of an ordinary Roman balance or steelyard."

Papin's method of determining the temperature is somewhat curious: "To know the degree of heat, I hang a weight to a thread about three feet long, and I let fall a drop of water into a little cavity made for that purpose at the top of it, and I tell how many times the hanging weight will move to and fro before the drop of water is quite evaporated!" As nearly all that we at present know about cooking, and extracting jellies by steam, is derived from the experiments of Denis Papin, we will close this portion of the subject by adding his description of one of them: "Having filled my pot with a piece of a breast of mutton, and weighed five ounces of coals, I lighted my fire, and by blowing gave such a heat that a drop of water would evaporate in four seconds, the inward pressure being about ten times stronger than the atmosphere. I let the fire go out of itself, and the mutton was very well done, *the bones soft*, and the juice a strong jelly. So that, having had occasion to boil mutton several times since, I have always observed the same rule, and never have missed to have it in the same condition, which I take to be the best of all.

"Beef required seven ounces of coal and the same heat, and the beef was very well boiled, although there were more parts of the bones not quite softened. Lamb, rabbits, and pigeons, mackerel, pike, and eel, were subjected to the same process; whence I infer that the bones of young beasts require almost as much fire as those of old ones to be boiled; that rabbit bones are harder than those of mutton; that tough old rabbits may be made as good as tender young ones by this means; that pigeons may be best boiled with a heat that evaporates a drop of water in five seconds; that mackerel was cooked with gooseberries, in a digester, the fish being good and firm, and the bones so soft as not to be felt in eating. I particularly recommend as an excellent dish cooked in this manner, cod fish and green peas."

Another application of steam that has proved very valuable on ship-board, is its condensation after having been evaporated from salt water, to supply the wants of passengers and crews when from accident or an unusually long voyage the regular stores are exhausted. The reader is probably aware that when salt water is evaporated, the steam therefrom is as pure as if taken from fresh, and would be as healthful and palatable as any other were it not from the fact that it does not contain the usual quantity of atmospheric air which has been expelled by heat. If, however, it is allowed to fall in the form of rain, or is poured from one vessel to another, it very soon absorbs a sufficient quantity and becomes as good as rain water, which, in fact, it is.

The application of steam to soften wood, so as to admit of its being bent into various shapes, is old; but by compressing the wood while being bent, so as to prevent the loosening of its fibre, great improvement has been made, and in the manufacture of furniture this has been of great service. There is also a Ship Timber Bending Company in Brooklyn, L. I., who are doing a large business in that line; the timber thus bent being quite as good as if of natural growth.

Steam bakeries, as they are called, show no new application thereof, as they simply consist of dough-raising and other machines driven by a stationary engine; we mention them simply to show how extensive are the uses of steam.

CHAPTER VII.

CONCLUSION.

To understand fully our indebtedness to the inventors and improvers of the steam engine, we must compare the past with the present. We must remember the North River sloops, the slow ocean packet ships, the lumbering coach; then the canal boat, the horse boat, the horse railroad; followed, but not yet entirely superseded, by the steamboats of Fitch, Fulton, Stevens, and a hundred others—each an improvement on the last—until months are crowded into weeks and weeks into days. If it is true, as some have said, that the duration of human life is less in each succeeding generation, it is incontestable, on the other hand, that the amount possible to be accomplished by each man in the same amount of time is increased many-fold. We have shown what has been done by steam; but are we now to stop and fold our hands at the request of the few old fogies who have been hurried along against their will, and now wish to sit down and take breath when the great work has but just commenced? No! American genius is the engineer of this locomotive, "Progress;" his hand is on the throttle-lever, which he opens wider each day. Conservatism may act as brakeman, but has no power to stop the train unless the engineer aid him. His bright, clear eye looks out upon the straight track—for the path of progress is only warped by foolish or selfish men—and conservatism may *brake* up and retard, but not stop the train. It will, it is true, take more steam to draw the load, while old fogies thus act as a drag, and they may rest assured that their action only renders the course of progress more dangerous, but will never stop it.

Lay down this vain opposition, then, and add your voice and your purse to aid the advance of steam; send your horses into the country, or retain them only for pleasure rides of invalids; pave your streets with iron, and harness steam to your drays and cars. We may not live to see it, but it is our firm belief that the time will come when the foolish excuse that steam will frighten horses in our cities will be no longer urged, for there will be no horses to frighten. You say that we are enthusiastic; so was John Fitch; does it then follow that he was wrong? You try to urge that there is more danger in steam than by the old mode of travelling, but this has long ago been proved false; and if there still are accidents from boiler explosions, it is your fault that they have not long since ceased. Pass a law in each state providing for the inspection of all steam boilers, and the examination of all engineers, and impose a heavy fine on all who hire an engineer who has no certificate. Do not make this a political movement, but see that the board of inspectors is composed of experienced engineers, men who can themselves pass an examination of the most strict nature; and bear in mind also that steam requires close attention, and that there is not one man in a hundred that can have the care of it, and at the same time have his mind distracted by other duties, without endangering the whole neighborhood. Powder mills are always located apart from other buildings, for a careless act would scatter destruction around; well, some of the boilers in New York at this present moment are worse than powder magazines, and yet they are located in the most densely populated parts of the city, and beneath sidewalks trod hourly by thousands. The engineer (?) saws wood, grooms horses, or works at the bench, while his pump clogs, and the water gets low in the boiler; or, interested in other work, he forgets to put the pump on, and soon after—longer, perhaps, than he is aware—he lets in the water, and wakes to find himself in a neighboring yard, or never wakes to see the effect of his employer's false economy. Under such management, who can wonder at the accidents we read of weekly; or, rather, what man conversant with the laws of steam does not wonder that there are no more "terrible calamities" to be recorded?

It is comparatively easy to understand the great advantages that have accrued to navigation and land transportation from the use of steam, for its effects are constantly before our eyes; but improvements from the use of steam in stationary engines are less apparent, although full as great. Even in the immense manufactories of Manchester and Lowell, where the water power seems almost unlimited, we find the steam engine at work; and all the water power of the United States combined would not be sufficient to carry out one branch of manufacture in all its details. If we now compete with foreigners in the manufacture of cotton goods, in spite of the low price of labor abroad, it is not only owing to our great improvements in cotton machinery, but also to the competition of our steam mills. And the steam press! Tiny

jets of steam puff forth from the offices of our smallest job printers, and ponderous engines work the six, eight, and ten cylinder presses of our large dailies. Ask the proprietors of those papers what they could now do without steam? The *New York Herald* has two engines to do the press-work; one built by Hoe is a beam engine of twenty-five horse power, the other is an upright engine of fifteen horse power, making in all forty horse. With these two engines they consume about one ton of coal per day, and throw off an average of 75,000 impressions. The office is, however, capable of doing much more than this, its utmost capacity being 48,000 impressions per hour. The engine rooms are very well fitted, and have two of Woodworth's donkey pumps; the one to supply the boilers with water, and the other, to be used in case of fire, is connected with hose in every room of the building.

The first steam mill that was erected in England was mobbed by the populace. They feared this giant competitor; they were afraid it would take food from their mouths; and we are sorry to say that this old feeling of the laboring classes is not yet entirely eradicated; educated Americans, who should know better, can yet be found to condemn machine labor. Last year Broadway was swept by a machine that would in time have been replaced by steam, but New York has taken a retrograde step, and politics have so strong a hold upon her citizens that progress must bide her time. Has the introduction of machinery hurt the laboring classes? That is the question! Are our laboring men worse off than before the introduction of steam? Look at the facts and the answer is plain. A few coachmen were thrown out of employment to make room for hundreds of employees upon the railroad, to say nothing of the thousands benefited by their construction, and that of the cars, locomotives, station-houses, etc. A handful of weavers and spinners have been temporarily removed, to be reinstated, with thousands of their fellow men and women, at full as good pay as before. Head has aided hands everywhere, and those who have kept up with the age of improvements have been, as they should be, the ones to profit by its advantages. But great as have been the improvements in our stationary engines, there is still much to do; we are not, in fact, living up to what we already know. The ordinary average of duty performed by our best stationary condensing engines is one horse power to four pounds of good coal consumed, while in marine engines it requires the consumption of four and a half pounds to the horse power; and yet engines are running that consume but two pounds to the same work. With these facts before their eyes, men continue to purchase the former, instead of looking for an improvement upon the latter; for even these results can be improved upon, as in our best boilers there is much of the combustible gases wasted, and much of the water evaporated into steam is condensed before it reaches the cylinder; any perceptible heat from the engine while working is, of course, so much loss of fuel. Bearing this in mind, enter an engine or fire room, and you will realize the loss from that source alone.

The first difficulty is being fast overcome by admitting atmospheric air above the fire, which unites with the gases as they rise, and furnishes the oxygen necessary for their combustion; it is now necessary to get rid of the heavy, incombustible gases, and this will soon be done. The radiation of heat can be prevented almost entirely by inclosing the boiler, cylinders, steam-pipes, etc., in some non-conducting substance; this is technically called "*jacketing*." Other improvements in the steam engine are being made every day, and we believe that the consumption of only one pound of coal to the hors epower will soon be accomplished.

In view of all the facts that have been adduced to prove that the steam engine is the best of all motors, can it be possible that there are still those who are sceptical on the subject of its utility? Alas, yes! You will find them among those who object to the use of steam in our streets to replace the horse cars; men who believe that new inventions must necessarily be humbugs, because in a few instances they have failed, and who cannot see that the greater number have added to their wealth, their comfort, and their pleasure. The greater number, say we? We might have said all; for if the first invention fail, it paves the way for another and better, and many of the failures of inventors stand as sign-boards to show the false paths. You will find these incredulous men in the same position to-day as were the throng of spectators who stood in Brown's ship-yard when the North River was fired up for the first time, loudly calling it "Fulton's folly." Its great success

soon quieted them for the time, but it was for a time only. A succession of surprises from that day to this should, it would be thought, have forever quieted them, but they "still live," and will only accept progress as a fact after repeated successes make it impossible to doubt; meeting each new plan with the same incredulity.

In speaking of the accessories of the steam engine, there is one point we omitted: many boilers are unprovided with steam gauges. In a conversation with a proprietor of a steam engine some time since, we asked him why he did not have a gauge upon his boiler. "Oh!" said he, "that is all nonsense; my safety-valve is weighted at one hundred, and my boiler would easily carry twice that steam. I have been without one for three years, and don't need it." We asked him if his engine was always competent to do his work, and if the latter was always constant. "Yes," he replied, "the engine will always do the work, but it is just all it will do. As for the work being constant, it is far from that; some days we do not run but half of our machines, and then the safety-valve tells its own story by 'blowing off.'" "Yes," we replied, "and it tells another story, which is 'loss of fuel.' Had you a steam gauge, the engineer would know how to fire, and in less than three months you would be able to pay for a gauge out of your savings." "Pooh! nonsense," he replied. Insisting upon the truth of what we said, we prevailed upon him to try it for a month with, and without a gauge, and so well satisfied was he with the result that he now says a gauge is worth two hundred dollars per year to him. This may have been an extreme case, for the engineer always knew when he came in the morning what machines were to be run, and he soon had an exact knowledge of the amount of steam required to drive them, and, therefore, regulated his fires by the gauge. Gauges will get out of order, we know, but they must be tested at least every three months by some standard, and repaired if wrong. Who wonders if so delicate an instrument should get out of order under one hundred pounds pressure for two or three years? and yet we can point to a gauge in use in this city that has not been tested for four. It is unnecessary to add, the proprietor "don't believe in gauges;" he probably expected it to last a life-time.

With regard to low water detectors, that whistle when the water is dangerously low, they must be used with great caution, for if out of order they would be a source of positive danger by the fancied security of the runner. After all, the only safeguard is a boiler in good order, and a competent engineer to take care of it; be sure on these two points, and nothing is better than steam to do your work. Those owning small engines object to paying the price of such men. Is it not better to pay more per day for absolute safety than to risk an explosion that will destroy all your property, and possibly your life and the lives of your workmen? If your work is not sufficiently profitable to pay a competent man, *sell* your engine and run your mill by horse power; better have a *mule* to turn the driving wheel than run the engine. But it will afford it; nay, in nine cases out of ten a good man will save more than his salary amounts to in fuel and repairs alone.

And now a word to engineers. You who are upon our steamships and locomotives think that such a law would be of no benefit to you; but you are very much mistaken; once passed, it would give employment to hundreds that are now competing with you for a position that is only sought because it offers better wages than stationaries can under the present system; under the same pay, men would prefer to run land engines, and be near home. Therefore, it is a duty you owe yourselves to insist, wherever you exercise the rights of suffrage, that your representative shall advocate such a law; make it the *sine qua non* of your vote. And you, engineers in name only, if you wish to retain your present positions, study your duty; learn why you do what you now mechanically perform; find out what pressure you are carrying, for yourselves, and do not trust to the marks on your safety-valves; read works on steam, and satisfy yourselves if they are true by, as far as in your power lies, testing them, for all that is printed is not necessarily true, as you will very soon discover. Above all things, be one to form an engineers' society, and discuss with men of experience the knotty points which will rise in your mind when you once begin the study of this potent vapor.

We cannot finish this article without referring briefly to another motor, which has for the last four or five years attracted some attention: we allude to the caloric engine. Mr. Ericsson, of whom we have already spoken, is the inventor of this machine. The

power made use of is the expansive force of heated air. For small engines this motor has been used with success, but in all Mr. Ericsson's experiments on a large scale it has failed. As there is no danger of explosion from the lack of water, the caloric engine has been of value on the southern plantations, as any one can run it, it being only necessary to make a fire, and see that the machine is oiled and kept in repair. We do not believe, however, that it will ever supersede steam as a motor, even for small engines. Since Mr. Ericsson's invention, others have followed with various improvements, and much ingenuity has been displayed upon the subject; we hear occasionally of some great success of a caloric engine, but it never results in any thing permanent. The details of the caloric are different from those of the steam engine, and the heavy boiler is done away with, but they are not as cheap if the cost of the boiler be excepted, and are much more liable to get out of repair; still, if properly taken care of they are useful, as we said before, in situations where but little power is required, and water scarce. Mr. Holly, so well known as "Tubal Cain" of the *New York Times*, says, in speaking of the caloric engine: "We only wish it was a better rival of steam in every particular, that it might compel the makers and users of boilers to employ better materials, better forms, and greater care in the management of the subtle motor—steam. And as its mechanism improves, as we believe it will, to some extent, year after year, it will better serve the public by compelling us to improve the smaller varieties of the steam engine, which, we believe, can also be made perfectly safe. The hot-air engine requires no constant or professional attendance, and for this reason is a valuable motor in cases where an occasional or auxiliary power is required. And for small purposes, the saving of engineer's pay more than balances the increased cost of fuel and repairs."

Undoubtedly small steam engines and boilers can be made perfectly safe; in fact, they should be the safest, and will be so, when the public will not look to the mere first cost alone, but will only buy engines of the best builders, and pay a fair price therefor; another result that we hope to see brought about by an inspection law. Nor is this by any means a small matter, for the unthinking man would be astonished at the amount of small stationaries that are now running throughout the country. In New York there are engines or boilers in every street; at our hotels and public buildings, in our printing offices, carpenter shops, as well as in all the larger manufactories and machine shops, engines of from two to five hundred horse power are daily running. Machinery of all kinds is driven by steam, from the large lathes and planers of our machine shops to the sewing machines of the clothiers; manufacturing crinoline in one place, and forging huge masses of iron in another, the busy hum of steam-driven machinery resounds on every side. Stand and look at the ten-cylinder press, and think of Franklin working at his old wooden one. Compare the speed of the former with the country press of only a few years back, if you would realize this great improvement. Has this hurt the printers as a class? Figure up the gross amount now paid to compositors, and compare it with the amount paid fifty years ago before you answer. Philadelphia is known as a manufacturing city, and one which is probably destined to be the greatest in this country. To what does she owe her prosperity? To the stationary engine, for she has no water power. We have already said, and we repeat, that imperfect though the steam engine may still be, it is by no means certain that water power is cheaper, and there is one disadvantage in the latter that is often overlooked, it is that of monopoly. The rich company who own the water power let it out at their own price, for there is no competition; but with the steam engine it is very different; if the price asked for power by your neighbor be too great, you can readily purchase an engine of just the power you require, and run it independently. But the greatest advantage of the stationary engine is that it can be used by the manufacturer at the door of the consumer, and the goods produced will be thus under his direct inspection.

Steam enters into the manufacture of every thing around us. The paper we write upon was dried by steam, our tin paper-cutter was rolled by steam, the chair we sit upon was turned and bent, the carpet was perhaps wove or at least dyed, and the wood work of the very room we are in, were all done by steam. Steam can warm our dwellings, and prepare our food. It tunnels mountains, and makes pins, cards, spins and weaves, coins our money, braids, twists, sews, washes, irons, and, in fact, enters into every

branch of industry. It has added more than any thing else to the wealth, power, and prosperity of our country. Think of this the next time you are asked to aid in any steam project, and as Americans have heretofore been among the first to perfect the steam engine, may they ever be the ones to educate it to new branches of labor. Be not satisfied with past improvement, but look forward to changes as great for the next twenty-five years, as there have been in the last half century.

APPENDIX.

EXPERIMENTS OF THE UNITED STATES GOVERNMENT.

In our introductory chapter we spoke of the use of steam expansively. Soon after the article was written, results were obtained by a series of experiments under the auspices of the United States government, that tend to the material alteration of engineering practice. As we had yet time, before this work went to press, we thought that some of the results, together with their bearing upon steam machinery, would prove acceptable.

Chief Engineer B. F. Isherwood, while trying some experiments in superheating steam, found that the results obtained by the use of steam expansively were by no means even an approximation to those theoretically claimed, and that a sufficient allowance was never made in calculating the increased loss from condensation. His experiments attracted considerable attention from engineers and steam-engine builders, and a petition, signed by some of the most prominent of them, was sent to the Hon. Isaac Toucey, the Secretary of the Navy, early in the fall of 1860. In reply to this memorial an experimental board was appointed, consisting of Chief Engineers Isherwood, Long, Zeller, and Stimers; and the United States steamer Michigan, then lying in her winter quarters at Erie, Pa., was placed at their disposal. She was made fast to the wharf, and so loaded as always to remain with a fixed draught of water, the coal burned being kept upon the wharf and brought on board as fast as used. Each bushel of coal was weighed, together with the ashes, clinkers, etc. The feed water was accurately measured in a large tank prepared expressly for that purpose. Every valve upon the two engines of the Michigan was carefully tested and proved tight, as were also the pistons, stuffing boxes, throttles, etc. The steam gauges consisted of two spring and two syphons, and were in good order. Indicators were placed upon each end of both engines. Thermometers were placed in the hot well, the feed-water tank, the engine room, upon the deck of the steamer, and in the water over the side. Diagrams were taken from each end of the cylinders alternately every half hour, and the average height of the barometers and all the above-named instruments was duly noted every hour by the officer on duty. A large number of experiments were tried, each of which occupied seventy-two hours. The fires were started and steam raised to a certain point (20 lbs. per square inch) before the experiment was commenced; and at its expiration the fires and pressure were brought to as nearly a similar condition as possible. In fact every care that experience and scientific ability could suggest was used, and we believe that any one who will examine the tables prepared by this board, will acknowledge that the nicest possible accuracy marked their entire labor. The experiments lasted about three months; one cylinder was tried at almost every point of cut-off with the initial boiler pressure at 20 lbs., and also with the initial cylinder pressure at the same point.

The deductions by the committee were, that at seven tenths of the stroke they obtained the maximum results; that cutting off steam at any shorter point than this is a loss, as proved both by the water and coal consumed; that the loss by condensation in the cylinder, and increased friction and back pressure, is generally greatly underrated; and that the use of a cut-off is no advantage over the common throttle valve in the majority of cases, and never sufficiently so to pay for its increased expense and the trouble attendant upon its use. These are a few of the most prominent of their deductions. They are contrary to the received opinions of most of the engineers from the time of James Watt to the present day, and from this fact are decidedly unpopular. We therefore do not expect in an article so general in its nature as this to convince the sceptical reader, but merely to state a fact that time will prove to the world. The following table is a digest of the first experiments,

but in order to get the entire data of the series, we shall be obliged to wait for the printed report of the board, which, if the present troubles at Washington do not prevent, will probably appear before the end of the present year; and to that we refer those sufficiently interested in the subject to wish to look further.

ONE ENGINE—BOTH BOILERS.

	Point of cutting off from commencement of stroke			
	One third.	13-14th stroke.	Two thirds.	One sixth.
Date of commencing	9 P.M., Dec. 5.	8 P.M., Dec. 10.	8 P.M. Dec. 13.	10 P.M. Dec. 16.
Duration of experiment	72 hours.	72 hours.	72 hours.	80 hours.
Pressure of steam in boilers in lbs., per square inch	20	20	20	20
Inches of vacuum in condenser	25.5	25.9	25.9	26
Lbs. per square inch of vacuum in cylinder	11.5	11.5	11.15	11.7
Mean effective pressure on piston, in lbs. per square inch	20.5	30.2	28 4	132
Revolutions per minute	11	13.6	14.3	9.
Indicated horse power	111	201	200	58.7
Lbs. of feed water per hour per horse power	43.3	42.7	37.9	54 25
Lbs. of coal per hour per horse power	5.85	5.46	4.89	6.64
Cost of power by these experiments, full stroke being unity	1.07	1.00	0.89	1.27
Cost of power as usually calculated, full stroke being unity	0.50	1.00	0.79	0.37

What interests the ordinary reader is this: accepting that the deductions are true, and that it is more economical to use steam at nearly full stroke than by cutting it off early in the cylinder, the following advantages will accrue—first, we shall build our cylinders smaller, costing less to construct and occupying less room, both of great importance to the marine engine—second, the other parts of the engine having a regular strain, instead of alternately crowding and being moved by the balance wheel, will bear to be much lighter. And, lastly, we are forever rid of expensive and complicated cut-off gear.

We cannot close this part of our theme without alluding to the course of Mr. Toucey in this mater. The experiments were so expensive that without government assistance they would probably have never been accurately tried, and the manner in which they were conducted will reflect as much credit upon the American government as was ever conceded to the French Academy for their celebrated experiments upon temperature and pressure. May the successors of Mr. Toucey ever show as much public spirit as he has done in this respect, and devote some of the public money to the advancement of steam engineering that has done so much for our prosperity.

COTTON MANUFACTURES.

CHAPTER I.

ORIGIN—HAND WORK—INVENTIONS.

THE use of cotton as a material for human clothing has been known since remote ages, not only in Asia, but among the ancient inhabitants of America. The kind of cotton used in the United States is a native of Mexico, and it was the principal material for clothing in use with the Mexicans at the time of the discovery of this country. They had neither hemp, wool, nor silk, but they wove the cotton into large webs, as delicate and as fine as those of Holland. These they ornamented with feathers and fur, wrought into the fabric in the form of animals and flowers. Cortes sent a number of these magnificent robes to Charles V. The art was apparently lost in the strife that followed, but the material transplanted to the United States about the time of the organization of the new government, has become a bond which holds modern Europe in dependence on American industry; a dependence which they would gladly shake off if they could, but which only becomes more hopeless in their efforts to do so. The cotton culture has produced a web which holds the lion in its toils, and his efforts to free himself, gigantic as they may be, only make his impotence more apparent.

The growing and manufacturing of cotton by machine took date from the organization of the United States government, and its progress has been as follows:—

	United States crop. lbs.	Cotton of other sources. lbs.	Total supply. lbs.	Price, Liverpool. cts.	Yards cloth.
1800,	9,582,263	45,671,170	54,203,433	48	162,610,299
1859,	2,162,000,000	199,446,616	2,361,444,616	6	7,004,333,646

The cotton from other sources is that imported into Great Britain from other places than the United States. The increase of supply is nearly all from the United States. The usual weight of cloth being three yards to the pound, the quantity of cotton spun would give in cloth the large number of yards seen in the table. This production employs a vast capital in the transportation, manufacture, and sale of the fabric. More people are now directly dependent upon the manufacture for support, than there were in the United States at the formation of the government. In the United States this year, 978,043 bales were manufactured, or equal to 1,470,000,000 yards of cloth, or forty yards to every person in the Union. The value of this must be $140,000,000. This has been the result of seventy years' progress from very small beginnings, and this marvellous growth has resulted from the extraordinary inventions that have not ceased to succeed each other, and of which we shall give a brief sketch.

The manufacture of cotton by hand originated in India at a time too remote for record, and it has there existed down to the present time in a rude state as far as machines are concerned, yet of an unapproachable and almost incredible perfection of hand production. Ancient writers speak of the "fairy-like" texture. Tavernier, two hundred years since, describes a calico that you "can hardly feel in your hand, and the thread is scarcely discernible." The Rev. William Ward states that muslins are made so fine that four months are required to make one piece, which is then worth 500 rupees ($250). "When this is laid on the grass, and the dew is on it, it cannot be seen." These are marvellous productions, doubtless, but they are possible only as a result of the organization of the people. They possess an exquisite sense of touch, and that gentleness and patience which characterize only an effeminate race. Even with them a long training is required in each district to perfect the cloth peculiar to it. This is a kind of industry that does not minister to the wants of a vigorous people in other climes. From India the manufacture spread to China, in the eleventh century, and found its way to Europe with the Mahometan conquests.

It was for a long time supposed and asserted by many philosophers that the Egyptians made cloth of cotton, and the mummy wrappers were asserted to be of cotton. It was not, however, until of late years, that the error was proved. The microscope reveals the fact that the fibres of cotton and flax are quite different. The latter is round and jointed, like a sugar cane, while cotton is flat and twisted. The mummy cloths are all of the first description, and there are no signs of a cotton manufacture in Egypt.

It spread through southern Europe sluggishly, and is first mentioned in England in 1641; but it made little progress until a century later. There were two obstacles to progress—want of the material and want of machines to manufacture effectively. The quantity of cotton imported into Great Britain early in the seventeenth century was about one million of pounds.

Up to the time of the American revolutionary war, the cotton manufacture in England in all its branches was in a very primitive state. At that date a series of inventions and discoveries took place, that rapidly carried the cotton manufacture to a magnitude second to no other industry, and gave it the impulse which, as we have seen, has not yet ceased to act. The cleaning, carding, spinning, weaving, dyeing, and printing were all conducted in slow and expensive methods, by which a great number of people were required to produce small results. The only source for the raw material was then the West Indies. The quantity derived thence was about 40,000 bales, or 4,000,000 pounds, and this was wrought up by hand processes.

The object in carding and spinning is to draw out the loose fibres of the cotton into a regular and continuous line, and after reducing it to the requisite tenuity, to twist it into a thread. By the early method, after the cotton was cleaned, it was carded between two flat cards held in the hand. A small quantity of the cotton placed on one was, with the other, combed as straight as possible. The fleecy roll that resulted was called a sliver. This roll, or sliver, was then applied to the single spindle, that was driven by a wheel set in motion by the other hand of the operator; as it received a twist, it was drawn out into a thick thread like a candle-wick, called a roving, and was wound on a cop. This roving was again drawn out and spun into a thread. Thus, in two operations, a single irregular and imperfect thread grew slowly in two hands. In this manner all the cotton yarn used was made, in cottages and private houses, mostly by females. The weaving was also done by hand looms; but such was the slow process of spinning, that the weaver's time was largely employed in going round to buy up yarn. They competed with each other in this, and the yarn thus cost more than it should. One fine morning Mr. James Hargreaves determined to emancipate himself from the spinners, by putting into practice an idea that had occurred to him. This was, to spin in his own house, and to make one wheel drive eight spindles, and to draw the rovings by means of a clasp held in the left hand of the operator. That was the first spinning-jenny, patented in 1767. In 1769, Arkwright added the important discovery of rollers, or drawing frames. This was one of the most important inventions. It consisted in causing the roving, on its way to the spindle, to pass between a pair of rollers about four inches long and one in diameter. These held the roving so firmly between them that it could pass only at the speed of their own revolution. From these the roving passed between two other rollers, which revolved twice as fast as the first pair. The effect was that between the two sets, the roving was drawn out to double its former length, and, of course, half its tenuity. The rollers thus supplanted the drawing by hand. By this mode of drawing the cotton, the fibres are straightened and made parallel; and the improvements that have since been made in the same direction are to increase the drawings and doublings, or the placing of several slivers together to be drawn down into one. In 1784, Crompton combined these two inventions into a third, called the mule-spinner. The machine of Arkwright was called the water-frame, because it was first driven by water power. The defect was, that it spun thread for warps only. It could not spin fine threads, because these could not bear the strain of the bobbins. This the mule remedied. Instead of the spindles being stationary, and the rovings movable, the former were placed upon a movable frame which runs out fifty-six inches, to stretch and twist the thread, and runs in again for it to wind upon the spindles. The thread is thus treated more gently. The effect of this machine is best understood by the fact that a "hank" of thread measures 840 yards, and it was before supposed impossible to spin 80 of these hanks from a pound of cotton. The

new machine spun 350 hanks to the pound, thus forming a thread 167 miles in length! This mule was improved to carry 130 spindles; and when water power was applied, in 1790, it carried 400 spindles. These mules, at the present day, carry 3,000 spindles, and are now self-acting.

The process of carding had also in this period undergone great improvements. The first improvement made in the old hand cards was to make one of them a fixture, and of a larger size than the other. The workman could thus work more cotton in the same time. He then proceeded to suspend the movable card by a pulley, with a weight to balance it. The next advance was to make the movable card a cylinder covered with cards, and turned by a handle, in a concave frame, lined also with cards, which was simply the fixed card curved to adapt it to the cylindrical form of the other. The lower part was let down in order to remove the cotton, by means of a stick with needles in it like a comb. The next improvement was in 1772, to attach an endless revolving cloth, called a feeder, on which the cotton was spread, and by it conveyed to the cylinder. The next step was to take the carded wool off the cylinder by means of another cylinder revolving in an opposite direction, and called the doffer. This being entirely covered with cards, gave a continuous fleece of cotton, which was in 1773 removed from it by means of a steel blade like a saw, working by short strokes. This broad fleece then passed through a funnel, by which it was contracted into a ribbon; it then proceeded through two rollers, that compressed it and let it fall into a deep can. The carding machine by these means approached perfection, but there was necessary to it the marvellous American invention of the card-making machine, which made the cards so perfectly and so cheaply as to make the cylinder carding possible. The concave frame in which the original cylinder revolved, was soon replaced by smaller cylinders covered with cards and revolving in a direction contrary to the main cylinder. Between the action of these, the cotton was more perfectly combed out.

The carding and spinning of yarn thus had become developed in a manner to meet the wishes of the weavers, but now genius was directed to the loom, and in 1785 the power loom was invented by the Rev. Dr. Cartwright. This was improved upon, until in 1803 a new loom was patented by Mr. Horrocks. These looms but slowly supplanted hand looms, notwithstanding their great superiority. The great obstacle to the success of the power loom was that it was necessary to stop it frequently to dress the warp as it came from the beam. The dressing is a size of flour and water, now used cold; the object of it is to make the thread smooth, like cat-gut. The inconvenience of the frequent dressing was remedied in 1802, by the invention of the dressing machine. By this machine the thread is wound from the bobbins upon the weaving-beam, and in its passage it passes through the starch. It is then pressed between rollers, and passing over hot cylinders to dry it, it is brushed in its progress. When wound upon the beam it is ready for weaving. The power loom thenceforth grew rapidly in favor. Before the invention of the dressing machine, one man was required to each loom; afterward, a girl of fourteen tended two, and produced with them three and one-half times as much cloth as the best hand weaver. Improvements were made, until, in 1833, a weaver fifteen years old, aided by a girl of twelve, would weave eighteen pieces of nine-eighths shirting of the same quality of which, in 1803, it required a grown man to make two in a week.

While these improvements in machines were made, there were discovered processes of bleaching quite as important. This process previously required six to eight months to steep in lyes and bleach upon the grass. By chemical discoveries, a bleaching powder, composed of manganese, salt, sulphuric acid, and lime, is effective in bleaching the rough, gray, and dirty fabric that comes from the weaver, in a few hours. Every thing is done by machinery and chemical agents.

The printing of calico was introduced into England in the seventeenth century, but made little or no progress until its introduction into Lancashire in 1764, when it was taken up by a farmer, Robert Peel, grandfather of the late prime minister of England, Sir Robert Peel. When he began to print, he had the cloth ironed out by one of his family, and used a parsley leaf for a pattern. The method was to cut the pattern upon blocks of sycamore, like an ordinary wood engraving. On the back of the block was a handle. The color was contained in a vessel, over which was stretched a woollen cloth, in contact with the liquid. To this the surface of the block was

applied, and it was then laid upon the white cloth ironed out, and struck with a mallet; the figure was thus impressed. The block was then applied in a fresh place; so that a piece of calico twenty-eight yards, required 448 applications of the block. To make more delicate figures, copper plates were employed, with the press used for copper-plate printing. The copper-plate method was quite as slow as the block method. In 1785, cylinder printing was invented. A polished copper cylinder, three feet in length and four inches in diameter, is engraved with the figure on its whole surface. It is then placed in the press, and as it revolves, the lower part passes through the coloring matter, which is scraped from the surface as it rises by a steel blade nicely adjusted lengthwise. This blade is called the "doctor." The cloth passes between this roller and a large cylinder, and receives the impression by a continuous motion. Thus, two or three minutes now sufficed to do what required before 448 applications. Almost any number of these cylinders may be used at the same time in the same press, and with different colors. Thus a five cylinder press will do what would have required 2,240 applications by the block; in other words, a man and a boy could now do what before would have required 200 men and boys.

An American invention here made an important change in the printing. Mr. Jacob Perkins, of Massachusetts, invented the process of transferring an engraving from a very small steel cylinder to the copper. Before this, the whole of the copper cylinder required to be engraved, at great expense, and when done would print about 1,500 pieces of cloth before it was worn out. By the new mode, a steel cylinder three inches long and one in diameter, is prepared by being softened that it may be easily cut. The pattern to be engraved is so arranged and made to agree with the circumference of the copper cylinder, as to join and appear continuous when repeated. When this is cut upon the steel it is hardened, and then, by great pressure against another soft cylinder, the figure is made on it in relief, or raised upon its surface. This being hardened, transfers by pressure the design upon the whole of the copper cylinder. The engraving is thus multiplied fifty-four times, and may be renewed at short notice when the cylinder is worn. This was a most important step in advance. When many colors are required in the same pattern, portions of it are engraved upon separate dies, and the number of colors may be multiplied by adding cylinders.

We have thus sketched the state of affairs down to about the period of the introduction of the manufacture into the United States, which was about the period of the formation of the government. The imports of the raw material into Great Britain at that time, will show the rapidity with which the trade developed itself.

COTTON IMPORTED INTO GREAT BRITAIN.

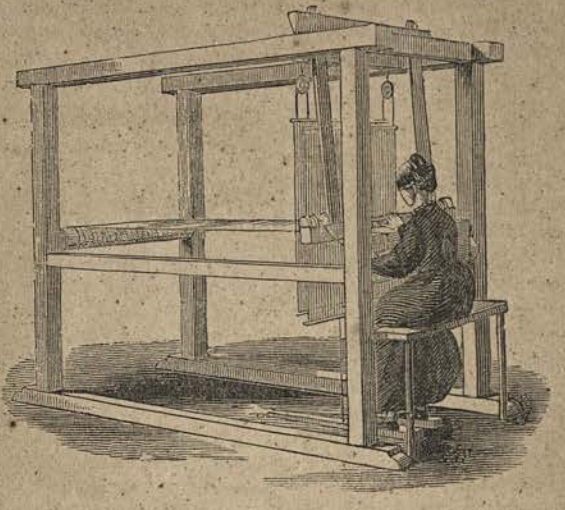
1775	4,765,589 lbs.	1786	19,900,000 lbs.
1781	5,198,777 "	1789	32,576,028 "

The cotton was derived as follows in 1786: British West Indies, 5,800,000 lbs.; French and Spanish do., 5,500,000 lbs.; Dutch do., 1,600,000 lbs.; Portuguese do., 2,000,000 lbs.; Turkey, 5,000,000 lbs. The United States contributed nothing. They did not then grow cotton.

The American invention of the cotton gin was more important than all the inventions we have described, for the reason that without it, and the American supply of cotton made possible by it, all the ingenuity of the English would have failed for want of material to work on. The sources of supply above mentioned have not increased in capacity. England has derived some cotton from India, but not so much in the raw state as she sends thither in goods, and the United States alone keep her mills in motion. While they have done this they have also developed the manufacture in a marvellous manner. We will here enumerate the dates of the above described inventions, in order to show that it was in the midst of the excitement they produced, that the manufacture was transported to America.

Hargreaves' jenny	1767
Arkwright's rollers	1769
Crompton's mule	1784
Feeding for carder	1772
Doffer " "	1773
Cartwright's loom	1785
Water power used	1790
Cylinder printing	1785
Dressing machine	1802

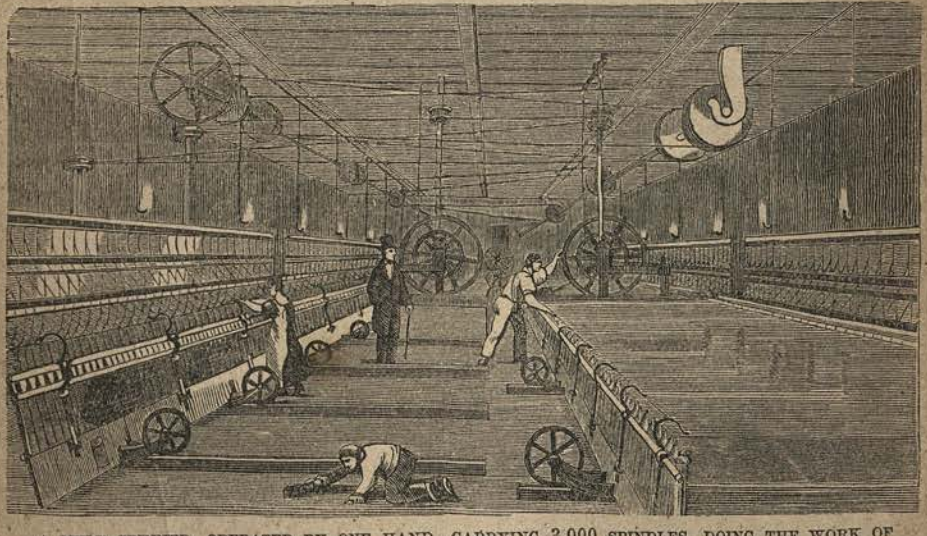
It was at the period so prolific in inventions, and when the use of cotton had so increased in England, that the manufacture was commenced in the United States. The first mill was at Beverly, Mass. It had a capital of £90,000, and was organized in 1787, for the manufacture of corduroys and



HAND LOOM.

POWER LOOM, ONE GIRL ATTENDS FOUR.

SPINNING BY HAND WITH A SINGLE SPINDLE.



A MULE SPINNER, OPERATED BY ONE HAND, CARRYING 3,000 SPINDLES, DOING THE WORK OF 3,000 GIRLS.

bed ticks. The capital was swallowed up in fifteen years. The machines were very rude, inasmuch as the new inventions in England were then unknown here.

CHAPTER II.

MANUFACTURE IN AMERICA—SPINNING—PROGRESS.

Samuel Slater was an apprentice to Jedediah Strutt, the partner of Arkwright. He served his time, and when of age departed for America, where he arrived in 1789. In the following year, he entered into partnership with Almey and Brown to start a factory at Pawtucket. Here, then, were put up, in the best manner, the whole series of machines patented and used by Arkwright for spinning cotton. There had been previous attempts at the spinning of cotton by water power, and some rude machines were in existence for spinning the rolls prepared by hand, in private families; but the machines that had been invented in England for the purpose were entirely unknown here until put up by Slater. Those machines were so perfect that, although put up in 1790, they continued to be used forty years, up to 1830, when they formed part of an establishment of two thousand spindles, which still exists in Pawtucket under the name of the "old mill." Slater's business was prosperous, and he amassed a large fortune. He died in 1834. His son and heirs still carry on the business. It is to be remarked that his business was confined to the spinning of cotton. The business, of course, spread as soon as it was found to be profitable; but, up to the war of 1812, the New England interests were commercial, and when the war broke out there was an immense rise in the value of goods, which gave to all existing spinning interests a great advantage. Cotton cloth sold at forty cents per yard; and Slater held almost a monopoly of the supply of yarn to make it. Mr. Slater had, in 1807, in connection with his brother John, who brought over important knowledge of the recent improvements in machinery, erected a mill near Smithfield, R. I., called Slatersville. Mr. Slater established a Sunday school for his operatives, and this is supposed to have been the first in New England.

It will be observed that Mr. Slater got his mill into operation in the same year that the federal government was organized under the new constitution, a most auspicious event. The circumstance did not fail to attract the attention of the new government, and Alexander Hamilton, secretary of the treasury, in his famous report of 1791, remarks:—

"The manufacture of cotton goods not long since established at Beverly, in Massachusetts, and at Providence, Rhode Island, seems to have overcome the first obstacles to success; producing corduroys, velverets, fustians, jeans, and other similar articles, of a quality which will bear a comparison with the like articles brought from Manchester. The one at Providence has the merit of being the first in introducing into the United States the celebrated cotton mill, which not only furnishes material for the factory itself, but for the supply of private families for household manufacture.

"Other manufactories of the same material, as regular businesses, have also been begun in the state of Connecticut, but all upon a smaller scale than those mentioned. Some essays are also making in the printing and staining of cotton goods. There are several small establishments of this kind already on foot."

The same report proposes, as an aid to the factories, to remove the duty of three cents per pound on the import of raw cotton, and to extend the duty of seven and a half per cent. to all cotton goods. It also remarks that cotton has not the same pretension as hemp to protection, as it is not a production of the country, and affords less assurance of an adequate supply. These few facts afford an idea of the notions then entertained of that cotton which has since overshadowed all other interests.

The old mill of Samuel Slater, Esq., the first building erected in America for the manufacture of cotton yarns, is a venerable wood-built structure, two stories in height, bearing numerous evidences of its antiquity, having been erected in 1793. Two spinning frames, the first in the mill, are still there, and are decided curiosities in their way. It is almost incredible to believe that this old building, time-worn and weather-browned, was the first to spread its sheltering roof over the young pupil of Arkwright, and that those dwarf frames, rusty and mildewed with inactivity, are the pioneer machines of that immense branch of our national industry—the manufacture of cotton goods. It may be

remarked that down to 1828 the exportation of machines of all kinds, and also wool, was strictly prohibited in England, for fear other nations should benefit by English mechanical genius, of which they supposed they had a monopoly; when, however, they found that the balance of genius was on this side of the pond, they liberally removed the prohibition. Mr. Slater, the father of American cotton manufactures, was so closely watched at the English custom-house, that he could not smuggle over a drawing or pattern. He had, however, acquired a full knowledge of the Arkwright principle of spinning, and from recollection, and with his own hands, made three cards and twenty-two spindles, and put them in motion in the building of a clothier, by the water-wheel of an old fulling-mill. Sixty-seven years have since elapsed, and the business has in that period increased beyond all precedent in the history of manufactures. Our rivers and wild waterfalls, that then flowed and murmured in solitude, are now propelling thousands of mill-wheels, and millions of shuttles and spindles. In the business, hundreds of fortunes have been made, thousands of citizens earn a subsistence and find constant employment, while millions are clothed in different portions of the globe. A wonderful revolution has that old mill produced on the shores of the new world. When Gen. Jackson visited the mill, and complimented Slater on his having been the first: "Yes," he replied, "here I gave out the psalm, which is now sung by millions."

The machines for the spinning of cotton thence spread into several states, and continued to attract capital. The extent to which this was carried became evident in 1810, from the facts collected by the secretary of the treasury, Albert Gallatin, Esq. The manufactures of cotton and wool were then principally confined to families; and Mr. Gallatin thought it probable that about two-thirds of the clothing (including hosiery), of the house and table linen worn and used by the inhabitants of the United States, not residing in cities, was the product of family manufactures. The number of cotton mills returned to the secretary, which were erected at the close of the year 1809, was eighty-seven, sixty-two of which (forty-eight water and fourteen horse-mills) were in operation, and worked at that time 31,000 spindles. The other twenty-five, it was supposed, would be in operation in the course of the year 1810, and, with the former, would probably work eighty thousand spindles at the commencement of the year 1811. He estimated the amount of capital that would be employed in these mills at $4,800,000, the cotton used 3,600,000 lbs., the yarn spun at 2,880,000 lbs., valued at $3,240,000, the men employed 500, and the women and boys 3,500.

By the returns of the marshals of the census of 1810, the number of cotton factories was 168, with 90,000 spindles; but from most of the states no returns were made of the quantity of cotton used and the yarn spun. Massachusetts had 54, most of them, no doubt, small, having in the whole only 19,448 spindles, consuming but 838,348 pounds of cotton, and their produce valued at $931,916. Rhode Island had 26 factories, with 21,030 spindles, and Connecticut 14, with 11,883 spindles. These were for the supply of yarn to be used in hand looms exclusively.

In this position of affairs the war took place; but just on its eve Mr. Francis C. Lowell, of Boston, returned from Europe, where he had inspected the great improvements in machines for cotton manufacturing, and had formed the project of establishing the manufacture in this country. He associated with himself in the enterprise his brother-in-law, Patrick S. Jackson, and they set about it. The country was then at war with England, and there was no possibility of getting either models or machines thence, nor even drawings. The memory of Mr. Lowell was all that was to be depended upon for the structure of the machinery, the materials used in the construction, even the tools of the machine shop. The first object to be accomplished was to procure a power loom. To obtain one from England was, of course, impracticable; and although there were many patents for such machines in our Patent Office, not one had yet exhibited sufficient merit to be adopted into use. Under these circumstances but one resource remained—to invent one themselves—and this these earnest men at once set about.

Unacquainted as they were with machinery in practice, they dared, nevertheless, to attempt the solution of a problem that had baffled the most ingenious mechanicians. In England, the power loom had been invented by a clergyman, and why not here by a merchant? After numerous experiments and failures, they at last succeeded, in the

autumn of 1812, in producing a model which they thought so well of as to be willing to make preparations for putting up a mill for the weaving of cotton cloth. It was now necessary to procure the assistance of a practical mechanic, to aid in the construction of the machinery, and the friends had the good fortune to secure the services of Mr. Paul Moody, afterward so well known as the head of the machine shop at Lowell. They found, as might naturally be expected, many defects in their model loom; but these were gradually remedied. The project hitherto had been exclusively for a weaving mill, to do by power what had before been done by hand looms. But it was ascertained on inquiry that it would be more economical to spin the twist than to buy it, and they put up a mill for about 1,700 spindles, which was completed late in 1813. It will probably strike the reader with some astonishment to be told that this mill, still in operation at Waltham, was probably the first one in the world that combined all the operations necessary for converting the raw cotton into finished cloth. Such, however, is the fact, as far as we are informed on the subject. The mills in this country—Slater's, for example, in Rhode Island—were spinning mills only; and in England, though the power loom had been introduced, it was used in separate establishments, by persons who bought, as the hand weavers had always done, their twist of the spinners. Great difficulty was at first experienced at Waltham, for the want of a proper preparation (sizing) of the warps. They procured from England a drawing of Horrocks' dressing machine, which, with some essential improvements, they adopted, producing the dresser now in use at Lowell and elsewhere. No method was, however, indicated in this drawing of winding the threads from the bobbins on to the beam; to supply this deficiency, the machine called the warper was invented, and there was now no further difficulty in weaving by power looms. The "double speeder," answering to the fly frame for spinning roving, was then added. Mr. Moody then invented the machine called the filling throstle, for winding the thread for weft from the bobbin on to the quills for the shuttle. The manufacture, as far as machinery went, was now on a permanent basis. The difficulty that presented itself was in operatives. There was here no such pauper class as that from which the English mills were supplied, and the factories were to be recruited from respectable families. By the erection of boarding-houses, at the expense and under the control of the factory; putting at the head of them matrons of tried character, and allowing no boarders to be received except the female operatives of the mill; by stringent regulations for the government of these houses—by all these precautions, they gained the confidence of the rural population, who were no longer afraid to trust their daughters in a manufacturing town. A supply was thus obtained, of respectable girls; and these, from pride of character, as well as from principle, have taken care to exclude all others. It was soon found that apprenticeship in a factory entailed no degradation of character, and was no impediment to a respectable connection in marriage. A factory girl was no longer condemned to pursue that vocation for life; she would retire, in her turn, to assume the higher and more appropriate responsibilities of her sex; and it soon came to be considered that a few years in a mill were an honorable mode of securing a dower. The business could thus be conducted without any permanent manufacturing population. The operatives no longer form a separate caste, pursuing a sedentary employment, from parent to child, in the heated rooms of a factory, but are recruited in a circulating current from the healthy and virtuous population of the country. The success which these mills met with of course prompted their extension. In 1821, Mr. Ezra Worther, who had formerly been a partner with Mr. Moody, and who had applied to Mr. Jackson for employment, suggested that the Pawtucket canal, at Chelmsford, would afford a fine location for large manufacturing establishments, and that probably a privilege might be purchased of its proprietors. To Mr. Jackson's mind the hint suggested a much more stupendous project—nothing less than to possess himself of the whole power of the Merrimac river at that place. Aware of the necessity of secrecy of action, to secure this property at any reasonable price, he undertook it single-handed. It was necessary to purchase not only the stock in the canal, but all the farms on both sides of the river, which controlled the water-power, or which might be necessary for the future extension of the business. Such was the beginning of Lowell, since so world-renowned. A new company, the Merrimac, was immediately established under the direction of Kirk Boat, Esq.

The establishment of the Lowell mills took place at a time when the occurrence of war had diverted the capital of New England from commerce, and it eagerly sought new modes of investment. These were presented in the promising prospects of the newly invented machine manufactures. The cotton growth of the south had become large before the war, and that event caused an immense accumulation of stock that sunk the price to the lowest point, and by so doing, offered an abundance of raw material at rates merely nominal compared with what the English manufacturers had been paying. This gave a great advantage to the new enterprise, and Congress aided it by the establishment of protective duties. The *minimum* cotton duty was invented for the purpose. The rate was nominally *ad valorem*, but the price was fixed at a *minimum*, on which the duty was cast—hence the duty was in effect specific. Thus, the abundant raw material, the low price of cotton, and the protection of the government, all combined to give breadth to the newly awakened manufacturing fever. The capital that crowded into it, soon, as a matter of course, overdid the business, and distress followed, which was sought to be relieved by a still higher tariff in 1824. That seemed, however, to add but fuel to the flame; and in 1828, still higher rates were demanded. We may compare these tariffs: cotton goods not dyed were to be valued at twenty-five cents per square yard, and pay twenty-five per cent. duty, or six and a quarter cents per yard; goods printed or dyed were to pay nine cents per square yard; fustians, moleskins, etc., were to pay twenty-five cents per square yard; woollens were charged twenty-five per cent. in 1816, thirty-three and a half per cent. in 1824, and forty-five per cent. in 1828. Under all these circumstances, the manufacture could not fail to grow rapidly, and of course to bring on distress as the result. In 1831, the tariff excitement had reached such a pitch that the most disastrous political results were anticipated. It was then that the committee of the convention collected information of the existing manufactures. They reported the table, which we annex. The returns are, for the eleven states where manufactures were well developed; some twenty to thirty other mills were also reported, but so imperfectly that the returns were rejected. The table is very valuable—as follows:—

STATEMENT OF THE NUMBER OF COTTON ESTABLISHMENTS IN THE ELEVEN FOLLOWING STATES, AND THEIR PRODUCTS IN 1831.

	Virginia.	Maryland.	Maine.	N. Hampshire.	Massachusetts.	Connecticut.	Rhode Island.	New York.	New Jersey.	Pennsylvania.	Delaware.	Total.	Machine shops.	Bleaheries.	Printeries.
Capital	$300,000	2,144,000	765,000	5,300,000	12,894,000	2,825,000	6,292,340	3,671,500	2,027,644	8,758,500	84,500	40,614,984	2,400,000	900,000	1,000,000
Number of mills	1	28	8	40	250	94	116	112	51	67	10	795			
Number of spindles	9,844	47,222	6,500	113,776	839,777	115,593	295,758	157,316	62,979	120,810	24,806	1,246,503			
Number of looms	91	1,002	164	3,530	8,981	2,609	5,773	3,668	815	2,192,865	295	38,516			
Pounds of yarn sold	869,000	1,104,000			807,966	487,900		1,867,790	8,212,154			10,642,000			
Yards of cloth	675,000	7,649,000	1,750,000	22,000,500	79,231,000	20,055,500	37,121,681	21,010,950	5,133,776	21,382,467	5,203,746	224,411,920			
Pounds of cloth	168,000	2,224,000	525,000	7,353,000	21,301,692	5,612,000	9,271,481	5,297,713	1,577,418	4,201,192	1,201,500	59,604,926	2,200		950
Males employed	143	834	54	875	2,065	1,399	1,731	1,874	2,151	6,545	697	18,359			619
" Wages per week	$2 73	3 87	5 50	6 25	7 00	4 50	6 25	6 00	6 00	6 00	5 00		7 50	6 00	7 00
Females employed	275	1,703	205	4,000	10,678	2,477	3,297	8,652	3,070	8,351	676	38,937		126	125
" Wages per week	$1 58	1 91	2 33	2 50	2 25	2 20	2 90	1 90	2 00	2 00	2 00			2 88	2 52
Children under 12 y'rs				60		439	8,472	484	217			4,691			432
" Wages per week				2 00		1 50	1 10	1 40	1 40						1 82
Pounds of cotton used	2,000,000	8,700	588,500	7,845,000	24,871,981	6,777,209	10,414,578	7,961,670	5,892,204	7,111,174	1,435,000	77,757,816			
Pounds of starch		874	15,000	164,000	907,480	187,135	824,908	81,030		975	750	1,641,253			429,625
Bbls. of flour for sizing	352		70	1,900	2,851	516	1,334	2,409		5,714	750	17,245			
Cords of wood	50	6,148		7,300	9,476	7,193	1,440	7,088	671	5,000	750	46,519			80,000
Tons of coal	200	65	400	1,500	2,621	247	1,410	488	1,007	16,814	763	24,430		19,250	2,250
Bushels of charcoal	1,000	400			4,635	3,250			830			9,205			
Gallons of oil		12,875	2,700	40,000	63,428	25,217	61,457	35,928	18,348	29,200	6,000	300,338		2,800	
Value of other articles	2,070	31,045	8,200	108,000	180,677	80,065	77,489	60,385	18,208	744,740	12,000	509,293	1,960,219	276,265	980,585
Total dependants	270	4,208	389	8,000	24,211	7,266	17,567	12,951	2,750	25,000	2,500	117,626	9,100	1,403	2,860

REMARKS.—Delaware includes $162,000, and Pennsylvania $500,000 for the capital employing the hand looms. The cotton consumed, 77,757,816 lbs., is 214,852 bales of the average weight of 361 86-100.

Such had been the immense growth of the manufacture in ten years from the time the Lowell mills were started, when but little machine cloth was made; but in 1831, there was made, it appears, 230,461,990 yards, or nearly twenty yards per head of all the people. It is obvious that this large and sudden production of cloth could have found vent only by supplanting the work of families and hand looms, and of course by pressing hard upon the spinners of yarn. The New England mills were mostly carried on as one concern, spinning and manufacturing together. This, however, is not the case with the mills in the middle or the new states. The mills there are mostly employed in spinning only, as were the first New England mills. The yarns are produced for sale to hand looms. The census of 1840 gave the number of mills in the whole country at 1,240, and the number of spindles at 2,284,631, consuming 132,835,856 lbs. of cotton; and the manufacture had continued to spread into the southern and western states. That was still hand weaving, which yet obtains in many parts of the older states of the Union. Thus, while in Pennsylvania the capital invested amounts to about one-seventh of that of Massachusetts, the quantity of cotton consumed is one-fifth; the value of the raw material, not quite one-fourth; number of operatives (male and female), one-fourth; value of products, rather more than one-fourth; the number of pounds of yarn spun and sold as yarn is above thirty times greater in Pennsylvania than in Massachusetts. This, to a certain extent, gives a key to the differences in the modes of manufacture in the two states. There can be no doubt, however, that domestic weaving is gradually giving way, and those manufacturers, especially in Pennsylvania, who formerly did a prosperous business as spinners only, now find that the eastern states supply the piece goods at a rate so little above the cost of the yarn, that it is not worth the while of the farmer to continue this primitive custom of weaving his own cloth. Thus the domestic loom is fast following the spinning wheel of the early settlers, and those manufacturers who until recently have spun yarn only, are gradually introducing the power loom as the only means of sustaining their position in the market. This was illustrated by the Eagle Cotton Mill, Pittsburg, Pennsylvania. Formerly, the proprietors spun yarn only, and did a successful trade; but, by a return which they made, it appears that in six establishments under their direction they had introduced already 540 looms to the 26,000 spindles, and were manufacturing sheeting at the rate of 6,000,000 yards per annum, together with twilled cotton bags, batting, and yarns, and this in order to make the latter pay, by consuming the surplus yarns themselves. In the Penn Cotton Mill, Pittsburg, the more modern system had become the rule of the establishment, and with 7,000 spindles and 207 looms, 2,730,000 yards of shirtings were produced annually, besides 240,000 lbs. weight of colored yarns for cotton warps and cotton rope. At two establishments in Richmond, Virginia, the consumption of the yarn in the manufacture of piece goods was the rule. Georgia, Tennessee, and North Carolina are quoted as those in which the greater progress had been made, while Virginia, South Carolina, and Alabama were the next. In Tennessee, spinning would appear to be the rule and manufacturing the exception; in Georgia and North Carolina, equal attention is paid to both; while in Virginia, South Carolina, and Alabama the manufacture of the piece goods is decidedly more extensively carried on than spinning; only slave labor is largely used, with free whites as overseers and instructors. The males are heads of departments, machinists, dressers, etc., and the females are spinners and weavers. The latter are chiefly adults, though children from twelve to fifteen are employed. The average hours of work here are twelve, but vary a little with the season, very full time being the rule. The James River Mill produces a large weight of work for the extent of its machinery. The goods manufactured are coarse cottons, and average about two and one-half yards to the pound, shirtings twenty-eight inches wide (osnaburgs), summer pantaloons for slaves, and bagging for export to the Brazils for sugar bags, running about three yards to the pound. Bagging of a lighter character for grain, and thirty-six inch osnaburgs, two yards to the pound, are also produced. The Manchester Company manufacture sheetings, shirtings, and yarns, and employ about 325 operatives; the children being of the same average age as at the James River Mill. Mr. Whitehead, of Virginia, in 1853, perfected a patent speeder. Its advantages are a greater speed, a more even roving, and a bobbin of any desirable size, which never becomes spongy in the wind-

ing. In Maryland, however, there were twenty-four establishments in 1850, chiefly engaged in the manufacture of piece goods, such as drillings, sheetings, ducks, osnaburgs, and bagging. The yarns produced for domestic purposes bear but a small proportion to those manufactured into cloth, and these are chiefly sold within the state for the home weaving of mixed fabrics of wool and cotton, forming coarse linseys. The wool is mostly spun by hand in the farm-houses, and the fabrics, when made, are intended entirely for domestic use. In Maryland, too, bleaching is carried on to a considerable extent. If the illustrations given show the early progress and position of this manufacture in the United States, so far as daily-recurring improvements and ever-increasing wants have permitted it to remain in its original form, the manufacturing towns of Lowell, Manchester, and Lawrence, strikingly demonstrate the results of the energy and enterprise of the manufacturers of New England. At Lowell, Mass., the cotton manufacture has been developed in a form which has been a theme for many writers on the economy and social bearing of the factory system; and the plans so successfully put into operation here and carried on since 1822 have led to the erection of large establishments, with their attendant boarding-houses, at Manchester, N. H., and more recently at Lawrence, Mass., while a commencement has been made at Holyoke, in the latter state, by the Hadley Falls Mill Company, which promises a result of a more extraordinary character than any thing yet achieved in the United States. Each of these localities presents features peculiar to itself, and besides the manufacture of cotton goods, other branches of production in textile fabrics are carried on. The falls of the Pawtucket on the Merrimack river and the Pawtucket canal, which had previously been used only for the purpose of navigation and connecting the river above and below the falls by means of locks, presented to the original projectors of Lowell a site for the solution of an important problem, not only in American industry, but to a great extent in that of Europe itself. This was the combination of great natural advantages with a large and well-directed capital, resulting in extensive and systematic operations for the realization of a legitimate profit, while the social position of the operative classes was sedulously cared for, and their moral and intellectual elevation promoted and secured.

The census of 1850 gave figures that show the extent of the manufacture as it existed at that date, in all the states. Those figures are as follows:—

COTTON MANUFACTURES OF THE UNITED STATES PER CENSUS OF 1850.

States	No. of Establishments.	Capital.	Cost of raw material.	Male hands.	Female hands.	Cost of labor.	Value of products.
Alabama	13	$681,900	$270,671	349	397	$89,520	$398,585
Arkansas	3	16,500	9,275	14	18	3,840	17,360
Connecticut	106	4,012,600	2,342,084	2,665	3,313	1,077,024	4,122,952
Delaware	12	585,100	314,768	413	425	134,304	538,439
District of Columbia	1	85,000	67,000	41	103	16,800	100,000
Florida	1	80,000	30,000	28	67	9,540	49,920
Georgia	29	1,398,256	832,804	816	1,291	225,180	1,395,056
Indiana	5	74,500	55,220	66	79	17,964	86,660
Kentucky	10	545,000	275,407	210	316	73,572	445,639
Maine	13	3,347,700	1,600,430	849	3,072	751,536	2,630,616
Maryland	33	2,248,600	1,353,361	1,212	2,035	435,768	2,021,396
Massachusetts	229	27,846,720	12,446,849	9,592	20,284	6,042,024	21,394,401
Mississippi	1	35,000	15,000	16	14	3,804	22,000
Missouri	2	102,000	86,446	75	80	19,440	142,900
New Hampshire	43	10,974,700	4,888,304	2,915	9,235	2,343,360	8,861,749
New Jersey	29	1,691,000	741,086	739	1,299	308,124	1,289,648
New York	118	5,554,320	2,888,465	3,379	5,499	1,443,780	5,019,323
North Carolina	35	1,327,400	629,118	492	1,372	169,272	985,411
Ohio	9	537,500	359,613	268	434	104,808	594,204
Pennsylvania	136	4,671,015	3,356,108	4,283	4,374	1,375,344	5,812,126
Rhode Island	159	6,572,195	3,515,769	4,847	5,901	2,031,036	6,495,972
South Carolina	19	902,600	401,921	436	676	155,472	842,440
Tennessee	32	647,272	291,080	316	592	97,536	508,481
Vermont	11	197,500	170,604	123	207	55,392	280,300
Virginia	25	1,898,200	836,681	1,151	1,578	282,672	1,446,109
Total	1,074	76,032,578	37,778,064	35,295	62,661	17,267,112	65,501,687

CHAPTER III.

INVENTIONS—MODE OF MANUFACTURE—PRINTING—AGGREGATE.

While the manufacture has thus spread over the face of the Union, the pioneer mills, or those which are erected in new localities, are generally employed in the spinning of yarn of coarse sorts; the old mills gradually spinning finer yarn, and attaching weaving and printing to their operations. In the whole period, however, of the past forty years, continued improvements have been made in machines and in power. Those mills that came into operation with fresh capital and the newest machines, had always advantages over those which still worked the old machines. The introduction of steam as a motor also favored the introduction of mills into localities that were not provided with water, and many persons contended that steam was cheaper and better even where water power existed. The latter was improved in its turn by the introduction of turbine wheels, which are a steady and sufficient power. The streams of New England were by art made to contribute in a wonderful manner to the work of factories. The works at Holyoke, Mass., are a singular instance of genius and enterprise. In the machines themselves, the greatest improvements have been continually made, in this country, as well as abroad. We have mentioned the American gin of Whitney, which, by enabling cotton to be cleaned, laid the foundation of the whole trade. The card-sticking machine, the steel die of Perkins, ring spindle of Jenks, the improved throstle of M'Cully, the tube-frame, the patent size of Mallerd, of Lowell, are among the most important of a crowd of inventions that have been made by American mechanics, and every few years a new mill starts in some quarter, with all these combined. The ring spindle of Mr. Jenks is very curious, and is producing important results. That gentleman was a pupil of Slater, and has an establishment for the manufacture of cotton machinery near Philadelphia, since 1810. On the starting of the Lowell mills, Mr. Moody invented a number of machines, viz: a loom, a filling frame, a double speeder, a governor, and also what is called the "dead spindle," in distinction to the "live spindle," which was the English invention. The dead spindle is mostly used in Lowell. Mr. Jenks' ring spindle is, however, superseding both, inasmuch as that it produces more and better yarn. The spindle of this improved frame has no fly, but has a small steel ring, called a traveller, about a quarter of an inch in diameter, with a slit for the insertion of the thread, which is wound by the ring travelling around the bobbin, being held in its horizontal plane, during its circuit, by an iron ring loosely embraced by its lower end and fastened upon the traversing rail, being sufficiently large to allow the head of the bobbin, as well as the traveller, to pass through without touching. This plan of spindle may be driven 8,000 revolutions per minute with perfect security when spinning coarse yarn, and when producing the finer numbers, 10,000 revolutions per minute is not an extraordinary speed for it to attain; the yarn produced in either case being superior in strength and character to the yarn produced by the other throstles at a greatly reduced speed.

The manufacture, as at present conducted, is a most beautiful and complicated art. The raw material is divided into long staple, medium staple, and short staple. The staple means simply the length of the fibre, and it is characteristic of the origin of the article. The first or long staple is used for the warps, or the longitudinal threads of a cloth. These threads must be made of long staple; no other kind of cotton will spin into the fine numbers. The medium staple is used for the "weft," or cross threads of tissues. It is softer and silkier than the long staple, and fills up the fabric better. The long staple will not answer for this purpose. The quantity of cotton in the weft of cloth is from two to five times as much as that in the warp. The short staple is used for weft, but it is harsher and more like wool, and after washing or bleaching it makes the cloth meagre and thin. It is mixed with the medium staple in small proportions.

This last and almost, when alone, useless sort is that which comes from India, and the first or long staple is "sea island," raised on the coast of Georgia. The medium staple, or that which is required for the great bulk of the manufactures, is alone found in the United States. It is that kind called "uplands," bowed Georgia, or New Orleans. The quality is a result of climate and soil.

The cotton having reached the mill, it is requisite that all of the same staple, but of different qualities, should be well mixed, to

give as uniform a character as possible to the cloth. To attain this, the contents of a bale are spread out upon the floor, and upon it another is scattered, and so on until a huge pile, called a "bing," has been raised; a rake is then used to scrape down from the sides, thus mixing the whole as the cotton is required for the mill. This cotton is matted together and filled with dirt, sometimes by design to increase the weight fraudulently. It must, therefore, first of all be cleaned and the fibres loosened. For this purpose several machines are used. The favorite is a patent Willey, which is composed of two iron axles on a level with each other, each having four stout steel teeth. The teeth of both axles mesh together as they revolve, and also the fixed teeth attached to the inner casing of the box which contains them. These axles revolve 1,600 times in a minute, opening out the fibres and beating out the dirt from the cotton, which is blown through a tube by a revolving fan.

The second machine through which the cotton passes is the spreading machine, the object of which is to perfect the cleaning and loosening of the fibres. The cotton being carefully weighed and spread upon the feeding apron, passes in between a pair of rollers, where it meets the action of blunt knives revolving 1,700 times in a minute. The cotton coming from this machine is flattened into a filmy sheet of uniform thickness, and wound upon a roller. It is of the greatest importance that this feeding should be done evenly, as otherwise the "lap," as it winds upon the roller, will have thin and thick places, which will run through the subsequent manufacture.

The laps that come from the spreader wound on rollers, are now to go through the third process, that of carding. The machine for this purpose we have described. It receives the end of the lap from the roller of the spreader, and by its operation combs out and straightens the cotton into a delicate fleece, which the "doffer" delivers through a funnel, whence it is drawn compressed, elongated, and consolidated by a pair of rollers, that drop it into a tin can. To the observer it appears like a stream of cream running into the tin can. For very fine yarns, this process is repeated with finer cards. The first carding is then called breaking.

The fourth process for the cotton is the drawing. Hitherto the cotton has passed only through male hands; with the drawing it passes into those of females. The slivers, as they are dropped into the tin can from the carding machine, are exceedingly tender and loose, and the fibres are not yet arranged in the position proper for the manufacture of smooth yarn. This is to be perfected by the rollers of the drawing frame; some frames have three pairs of rollers and others four. The distance between the pairs of rollers is such that the longest fibre of cotton will not reach from the centre of one roller to that of another pair. This prevents breaking the fibres, but the rollers must not be too far apart, lest the cotton separate in unequal thicknesses. The "doubling," by which the end of a new sliver is laid on the middle of one running in, equalizes the sliver. The more it is doubled and drawn, the more perfect is the yarn, and this doubling is done sometimes 32,000 times.

The fifth operation is the roving, or first spinning process. The slivers under the action of the drawing frame become so thin and tender they will no longer hold together without a twist, and many machines are used for the purpose of imparting it, under the names of slubbin, fly frame, belt speeder, tube frame, and others. The operation is performed one or more times, according to the fineness of the yarn desired. The cans which receive the slivers from the drawing frames are placed upon revolving wheels, and the sliver passes from these to the fly frame. This came into use in 1817. In this frame the spindles are set vertically in one or two rows at equal distances apart, each passing through a bobbin, which is loosely attached to it, and which has a play equal to its length up and down on the spindle; at the top of the spindle is suspended a fly with two dependent legs, one solid, and the other hollow. The roving enters this by an eye immediately above the top of the spindle, and passing down the hollow leg attaches to the bobbin. The revolving spindle carries the fly with it, spinning and winding the roving at the same time. At this point enters a very nice calculation. The roller on which the roving is wound delivers it with the exact speed of the spindle, but as the size of the bobbin on the latter increases, it going at the same speed would take up the yarn faster than the roller would deliver it, and would strain it too much. This is avoided by a contrivance which varies the speed of the bobbin to meet

the circumstances. The rovings having received this twist, are now to be spun into yarn, and this is done either by the throstle or the mule spinner. The difference in the motion and structure of these machines is not great. The former is similar to the bobbin and fly frame. The roving being unwound from the bobbin is elongated between three pairs of rollers, and is then spun and wound upon a bobbin as before. The greatest difference in these machines is in the spindles. The oldest is the live spindle, and the dead spindle is that invented at Lowell, and that which has been most used here. The ring spindle of Jenks is fast superseding both. The thread being spun by any of these means is wound upon bobbins, and these are then set in a frame in such a manner that the threads can be wound off from them on to a large six-sided reel. This, one and a half yards in circumference, makes 560 revolutions, giving the length of a "hank;" many hanks are wound on the reel at the same time, and when these are removed and weighed they give the number of the yarn. The coarsest yarn weighs half a pound to the hank, or 840 yards; common quality gives ten to forty hanks to the pound. The finest seldom exceeds 300 hanks to the pound. Previous to 1840 no yarn finer than 350 was made in England; at the World's Fair there was some exhibited 600, and some muslin for a dress for the queen was made of 460 yarn. This exceeds the "fairy tissues" of the east, mentioned in the fore part of this article. Thus machinery has overtaken eastern hand art. It has been stated that yarn has been spun 900, and one specimen of No. 2,150, or 1,026 miles for a pound of cotton!

The finest yarns are singed by being run through a gas flame; they are then passed over a brush and run through a hole in a piece of brass just large enough to admit the yarn. Any inequality then stops the yarn and is immediately remedied. Upon most of the machines, throstles, and feeders there are clocks, which, wound up once a week, mark the quantity of work that each machine does. From this register the account is transferred to a board which hangs in sight of all the operatives, and from which the monthly wages are ascertained.

The yarn, being spun, the filling is now ready for the weaver, but the warp goes to the dressing-room. Here the yarn is warped off from the spools on to the section beams. This is considered hard work, since it requires unremitting attention to reconnect the threads that are constantly breaking. The yarn now upon the beams undergoes "dressing," or the application of the size before mentioned, and the friction of the brushes. The beams containing the dressed yarn go to the weaving-room, which usually is a large mill containing one hundred and fifty girls, and some six hundred looms. From this room the woven fabric goes to the cloth-room, where it is trimmed, measured, folded, and recorded, and either baled for market or sent to the print-works.

The print-works are a most interesting portion of the manufacture. The cloth received from the manufactory is covered with a fine nap, which, if printed, would rise up and give the colored parts a pepper-and-salt look. To get rid of this, the cloth is singed; not as the cook singes a fowl, by a blaze, but by running the cloth over a half-cylinder of copper, heated red hot. The cloth is passed over dry, and repassed; after which it is moistened by wet rollers, to extinguish any shreds which might happen to be on fire. This singeing process always excites the wonder of the beholder, who is not a little astonished that the cloth is not injured. The next process is to bleach the cloth. On the success of this depends all the after-work. A good white is not only the soul of a print, but without it no good and brilliant color can be dyed. The greatest difficulty is to remove every trace of grease and oil, imparted by the spinner and weaver. The cloth is, therefore, put into big tubs, holding five hundred pieces, and steeped in warm water some hours. It is then washed in the dash-wheel, and subjected to the following operations, which convert the oil to soap, and remove with it the coloring matter:—

1. Boiled by steam in a creamy lime.
2. Washed in the dash-wheel.
3. Boiled in alkali by steam.
4. Washed in the dash-wheel.
5. Steeped in bleaching-powder solution some hours.
6. Steeped in oil vitriol and water, about the strength of lemon juice.
7. Washed in the dash-wheel.
8. Squeezed between rollers.
9. Mangled and dried in air, or in warm rooms built for this purpose.

The cloth is now perfectly white, and loses not so much in weight and strength as by the old process of grass bleaching. The bleached cloth is now printed with one or

more colors. Four to six colors only could be applied by the printing machine up to 1845; if more were wanted, they were, until recently, introduced by hand, with blocks, after the other colors were finished. By a Boston invention, patented in 1851, twelve colors may now be printed. The improvement consists in the mode of applying pressure to the print rollers. A yielding pressure of several tons is given to each roller. The frame is also so constructed that any one of the rollers may be removed from the machine without disturbing the others. The machine weighs ten tons, and is ten feet high. This huge machine is so nicely adjusted that the cloth, while passing through it at the rate of a *mile per hour*, receives twelve colors each with the utmost precision. Ordinary machines will print 300 pieces, or 12,000 yards, per day, while, by the old hand process, it would have required 192,646 applications of the block. The figure, or design, is engraved on a copper roller, each color having a separate roller. The color which the beholder sees imprinted, as he watches the process, is not the color that is to be, when the print is finished. The color which he sees is, with the exception of brown, or blue, or black occasionally, fugitive. It is merely what is called "sightening"—that is, a color imparted to the paste, or "thickening," which is imprinted by the roller to enable the machine printer to judge of the perfectness of the work. The paste, or *thickening*, contains the mordant—that is, the peculiar substance which, combining chemically with the cloth, enables it to dye a peculiar color, according to the nature of the mordant and dye-wood. The cloth dyes only where the mordant is applied—that is, on the printed figure only. The mordants generally used are alum and copperas, each of which is first changed to *acetate of alumina or iron*—that is, the color-maker takes away the oil of vitriol from the alum and copperas, and substitutes vinegar in its place. Sometimes the *iron liquor*, as it is called, is made by dissolving iron turnings in pyroligneous or wood acid. The preparation of color, and the thickening it with flour, starch, gum, etc., is a distinct branch, carried on in the color shop of the print-works. It may be added, that with madder, iron dyes black and purple, according to its strength; alum dyes red of various shades; and a mixture of the two dyes chocolate. So that out of the same dye-kettle come various colors, according to the mordant, and these colors are all fast.

The cloth having been printed and dried, is "aged," during which a chemical combination takes place between the mordant and the cloth. Ordinarily, this occurs in two or three weeks by a natural affinity of the cotton fibre and mordant, but by certain agents, this chemical change is hastened and perfectly effected in two or three days; yet as this process goes on in conjunction with the others, the visitor sees only the folding up and winding into rolls of the piece of cloth, though all the time this change is going on. The cloth is then passed, by means of rollers, through a boiling hot solution of *phosphate of soda*, to render insoluble any uncombined mordant, and to wet the cloth evenly. It is then washed in the dash-wheel, and after this, to remove the *thickening*, passed for twenty or thirty minutes through bran or meal and water, quite hot, washed, and it is now ready for dyeing. The dye-woods used are madder, bark, or logwood—the last only for mourning prints, or black and white. The dye-wood is put into large wooden vats, with a portion of water, and then the pieces of cloth, sixteen in each vat, are introduced over a winch, moved by water power. Steam is then admitted, the goods turned through and through, round and round, gradually heating the water, till at the end of two hours it rises near to boiling, and the mordanted cloth is perfectly dyed. It is taken out, rinsed, and washed in the dash-wheel. The cloth after this is passed, by means of a winch, either through hot water and bran or through hot soap, for half an hour, washed, and then again put through these operations, again washed, and then rinsed through a hot solution of chloride of soda, washed again, squeezed, and dried in either air or in warm rooms. Sometimes they are mangled with some stiffening, and so are finished. The visitor of print works will see a great number of men busily employed dipping wooden frames, on which are stretched pieces of cloth, printed with a brown figure, into deep vats, filled with a green-blue liquor. The cloth comes out with a *greenish* hue, and immediately grows blue in the air on all parts, except where the brown figure was. That *resists*, or *throws off* the blue vat. Now, the blue vat contains a solution of indigo in lime water. Indigo is one of the most insoluble substances in water;

but by means of copperas and lime, the oxygen of the indigo is abstracted by the iron; it then becomes greenish and is dissolved by the lime-water. Exposed to air, it again absorbs oxygen and becomes blue. It is during this change from green to blue that it becomes chemically united to the cloth. The brown figure *resists*, because it is a preparation of copper, which yields its oxygen to the indigo on the figure while in the vat. The figure becomes covered with blue indigo in the vat; it forms then no affinity with the cloth, and consequently after the copper has been removed by a weak acid, the brown spot or figure remains white, and so is produced the blue ground with white figures. The whole is a most exquisite chemical process from beginning to end, equalled only by the process for China blue, where blue figures are raised on a white ground. This is done by printing on the figure with fine ground indigo thickened with paste, and thus by alternate immersions in lime water and copperas liquor, the indigo is dissolved and fixed on the spots where printed, by a play of chemical affinities similar to those described in blue dipping. Black and white, and red, or chocolate and white, are made by passing the cloth through red or iron liquor, or their mixture, and after squeezing, while the cloth is open and flat, that is dried in hot flues. Every part of the cloth is thus imbued with mordant. The process is termed "pading." It is then printed with citric acid (lemon juice) thickened with roasted starch. This acid discharges the mordant, and consequently, when dyed as usual, the discharged figures are left white. Logwood is the dye for black, and madder is the dye for reds and chocolates. The designing of patterns is a distinct branch of art. Usually, one or more designers are employed in each establishment.

In the year 1840, there were thirty-six cotton-printing establishments in the United States. These were in New Hampshire, Massachusetts, Rhode Island, New York, New Jersey, Pennsylvania, and Maryland. They printed 100,112,000 yards, at a value of $11,667,512.

The exports of cotton goods from the United States in 1827 were valued at $951,060 for plain white cloths; $45,120 printed and colored; $163,293 for yarn, etc.; making together $1,159,413. In 1857, the exports of white had run to $3,463,230; and of printed to $1,785,685; dark and other manufacture, $866,262; together, $6,115,117. The American cottons are much in demand in China, in consequence of their heavier quality than the English or Chinese goods. The value of cotton goods imported in 1856 was $25,917,999; and the average for the last sixteen years was $16,758,418. The value per head of United States cotton goods consumed was, for 1856, $2.40; and of foreign goods, sixty cents. The imported goods are mostly of the finer description, nearly all from England and Scotland, and mostly into the port of New York, under the credit system of sales.

We may here add the progress of the trade in Great Britain, as it is given in the factory inspector's official report:—

	Horse power.	Spindles.	Looms.	Cotton used. lbs.
1851.	134,217	25,638,114	301,445	737,379,749
1857.	161,435	28,508,580	369,205	1,023,886,528

The following comparative figures will show the decline in the cost of the yarn, as a result of machinery:—

No. 40 yarn.	1812.	1830.	1857.
Hanks per spindle per day.	200	275	275
Cotton per lb.	$0 36	$0 14	$0 12
Labor " "	0 24	0 15	0 10
Cost yarn "	0 60	0 29	0 22

The manufacture progresses in this country according to the wants of the population, and these wants increase in the two-fold ratio of more means and greater numbers. The progress here is also more steady than it is abroad, for the reason that the demands of the people are not curtailed by those periodical famines, which abroad cause every other consideration to yield to that of food. We may sum in the following table the progress of the manufacture since 1809:—

COTTON MANUFACTURE IN THE UNITED STATES.

	No. of Factories.	Spindles.	Hands.	Cotton used. lbs.	Yards cloth made.	Capital.
1809	62	31,000	4,000	3,600,000	..	..
1810	168	90,800	.		..	..
1820	..	250,572	..	9,945,609	..	..
1831	795	1,246,503	57,466	77,757,316	230,461,990	$40,614,984
1840	1,240	2,284,631	72,119	132,835,856	398,507,568	51,102,359
1850	1,580	4,052,000	97,956	276,074,100	828,222,300	76,032,578
1860	1,700	6,400,000	110,000	449,899,780	1,349,699,340	110,000,000

The figures for 1809 are those of Mr. Gallatin, and those of 1810 those of the United States marshal, also those for 1820. Those for 1831 are of the committee alluded to, and the succeeding ones of the census, except for 1860, in which year the quantity of yarn taken by the spinners only is known; the other figures for that year are those which are proportional to the quantity of cotton bought. The above table shows that in 1830 the cotton spun was six and a half pounds per head of the population; in 1840, eight pounds per head; in 1850, ten and a quarter pounds per head; and in 1860, fifteen pounds per head, being in the double ratio of numbers and wealth, and showing that the United States are the largest consumers of cotton goods in the world. The United States now consume nearly as much raw cotton per annum as Great Britain did in 1838–9; that is to say, Great Britain at that date consumed 442,691,877 lbs., and the United States this year 449,899,780 lbs. Thus the manufacture in the United States this year for home consumption equals what Great Britain produced for home consumption and her vast export trade in 1839, or twenty years since. In this progress of manufacture there has been a steady decline in price. In 1815 the price of cotton cloth was forty cents; in 1822, twenty-two cents; and at this time four to ten cents. In those figures we have the secret of the great dissemination of machine goods. The price of a good calico is now twelve yards to a bushel of wheat. Forty years ago, it was one yard for a bushel of wheat. The quality of the goods at the same time has improved in a greater ratio. The handsome prints that now replace the "factory checks" of that day, show as great a change as does the price.

PAPER: ITS MANUFACTURE.

CHAPTER I.

MATERIALS—PROGRESS.

If the question were put, "What single article has been of the greatest service to mankind?" mature reflection would, we think, decide upon paper as that article, since it has been the means by which thought and ideas have been diffused, not only among cotemporaries, but preserved, and, as it were, accumulated in magazines for future expansion and growth. All other inventions, and perhaps the whole growth of civilization, are due to the material of paper. Every branch of knowledge is reached, and every avenue to the wisdom of great minds and the results of genius are explored only by means of paper, and its blessings are diffused through all ranks of society. Even he who, wrapt in his ignorance, despises "book larning," enjoys a part of those benefits of civilization which paper has been the means of imparting to all. Like almost all great blessings, however, it has been developed most rapidly and completely in the United States. Almost all vegetable substances were used for the manufacture of paper by our ancestors, but it was not until the fourteenth century that linen rags became generally the material. The first German paper mill was established at Nuremberg in 1390; some English manuscripts, however, date as far back as 1340, on linen paper. The first English mill mentioned is in 1496, by John Tate, jun., in Hertfordshire. In 1588 a paper mill was started at Dartford. It is to be conceived, however, that in that age, when books and newspapers were little used, and walls were draped with cloth, that paper was not much in demand, and many improvements were not made in the manufacture. In the early part of the eighteenth century, the manufacture was introduced into the colonies. Mr. J. M. Willcox, a paper maker near Philadelphia, stated that in 1725 his grandfather, who had been educated a paper maker, came over and settled where the mill now is, and he erected in 1732 a mill for the manufacture of paper. The kind of paper then made was of the description used by clothiers for press-boards, for the pressing of cloth. There existed at that time an act of parliament against the manufacture of any other kind of paper in the colonies. There were at that time two other mills in the same

business, one near Boston and another near Philadelphia. The demand for paper at that time, either for books or newspapers, was small, and not of a character to attract much capital into the business. When the war came on, a demand sprung up, and Mr. Willcox manufactured the paper for the continental money, and at the same time commenced making writing paper for the first time in America.

The Massachusetts Bay assembly, in 1728, passed an act for the encouragement of the paper manufacture. They granted to Daniel Henchman and others the right of making paper, on condition that within the first fifteen months they would make 140 reams of brown paper and sixty reams of printing paper. Of this the board of trade report of 1731 says: "By a paper mill set up three years ago, they make to the value of £200." This, with the mill of Willcox and another near Philadelphia, were the only ones existing at that time; but the trade grew to a considerable extent. Coxe, in his "Views of the United States," says there were in 1794 forty-eight mills in Pennsylvania. In 1810, the value of paper made in the United States was about $2,000,000. The general government, from its origin, did what it could to encourage the manufacture, by making rags free; curiously enough, however, after the fall of Napoleon, a considerable quantity of paper came to this country, and was bought up by the contractors to supply Congress; and for a long time, up to 1825, the paper used by the United States Senate bore the water line, "Napoleon, Empereur et Roi, 1813."

It was about the year 1760 that the invention of wove moulds was made to obviate the roughness of *laid* paper. This led to the manufacture in France of what is called vellum paper. In Holland, soon after, the manufacture was improved by the invention of cylinders with long steel knives to reduce the rags to pulp, thus superseding the old plan, which was by stampers. It was then customary to pile the rags in large stone vats, and let them remain for a month or six weeks to ferment and rot by soaking and stirring in water. By these means the fibres became loosened, and sufficiently soft to be reduced to pulp in the large wooden stampers. The *vats* were now supplanted by *engines*. These are arranged in pairs. That which first receives the rags is called the washer, working the rags coarsely, while a stream of water runs through them. The contents of this vat, when ready, is called *half stuff*, and is let off into the other engine, which is on a lower level, and this beats or grinds the whole into pulp for making paper.

From the date of the Revolution until the year 1820, there was very little improvement in the mode of making paper by machinery. The number of mills increased in proportion to the demand for material for newspapers and book-making. This grew in such a manner, that by the year 1810 the ordinary supplies of material for paper making began to fail, and rags from Europe were imported in greater quantities for that purpose. The principal supplies of rags in the United States came from the economy of families, purchased by ragmen who called—sometimes paying money, and at others exchanging tinware and other commodities. It is only of late years, and that in the large cities, that the European *chiffonniers*, or rag-pickers, have made their appearance. These are now to be seen, male and female, with the early dawn, armed with a bag and a long iron hook, watching the opening and sweeping out of stores, to pick up every shred of rag or paper, and following the gutters the live-long day, thrusting the iron hook into filth of all descriptions to fish out matter for the paper maker. This they rinse in the nearest puddle, and deposit in their bag. Many of them earn a fair living at this unpromising occupation. Nevertheless, the supply is very inadequate, and large importations are resorted to. The quantity of imports is as follows:—

IMPORTATION OF RAGS INTO THE UNITED STATES.

	Rags imported. lbs.	Of which from Italy.	Value.	Per lb. cts.
1846,	9,897,706	8,002,865	$385,020	3.89
1847,	8,154,886	6,529,234	304,177	3.73
1848,	17,014,587	13,803,036	626,136	3.68
1849,	14,941,236	11,009,608	524,437	2.51
1850,	20,696,875	15,861,266	747,157	3.61
1851,	26,094,701	18,512,673	902,876	3.46
1852,	18,288,458	12,220,579	622,876	3.42
1853,	22,766,000	14,171,292	985,465	4.31
1854,	32,615,753	24,240,999	1,007,826	3.69
1855,	40,013,516	23,948,612	1,224,413	3.06
1856,	38,727,017	20,817,204	1,239,168	3.20
1857,	44,582,080	27,317,580	1,448,125	3.27
Total,	293,192,815	196,404,948	$10,016,014	

It may be remarked that the export of linen rags is strictly prohibited from Holland, Belgium, France, Spain, and Portugal. The import from Italy has been nearly 70 per cent. The rags thence derived are mostly linen which has been used for outer gar-

ments, and which have become whitened by exposure to sun and air. That circumstance formerly gave them a value, which they have lost since the improvements in bleaching all descriptions. The linen rags from the north of Europe are stronger and darker. The quantity of rags used in the United States in 1850 was, according to the value reported in the census, nearly 200,000,000 lbs., and 20,696,875 lbs. were imported in that year. The importation has, it appears, since more than doubled, and it is now estimated that the quantity used is 400,000,000 lbs.; and as one and a half pounds of rags give one pound of paper, the product would be 270,000,000 lbs. This, compares with the English and French returns as follows:—

	Rags consumed. lbs.	Paper made annually. lbs.	Lbs. per head consumed.
United States....	400,000,000	270,000,000	10.80
Great Britain....	436,800,000	291,200,000	4.55
France.....	235,200,000	140,083,447	3.89

At one time there were serious apprehensions that the supply of linen rags would fail, and various researches were entered upon by ingenious individuals to find substitutes. A book written in Germany by M. Schäffer, so long ago as 1772, contains sixty specimens of paper made of different materials. This ingenious person made paper from the bark of the willow, beech, aspen, hawthorn, lime, and mulberry; from the down of the asclepias, the catkins of black poplar, and the tendrils of the vine; from the stalks of nettle, mugwort, dyer's weed, thistle, bryony, burdock, clematis, willow-herb, and lily; from cabbage-stalks, fir-cones, moss, potatoes, wood-shavings, and sawdust. Paper has been likewise made from straw, hopbind, liquorice root, the stalks of the mallow, and the husks of Indian corn. These experiments are now continued, and an attempt to make paper from reeds has recently been made in Baltimore. The process of bleaching the coarser rags, so as to render them fit for the purposes to which only those of the finest qualities were formerly applied, will, however, render the use of these inferior substances unnecessary for many years. The advance of a people in civilization has not only a tendency to make the supply of rags abundant, but, at the same time, to increase the demand. The use of machinery in manufactures renders clothing cheap; the cheapness of clothing causes its consumption to increase, not only in the proportion of an increasing population, but by the scale of individual expenditure; the stock of rags is therefore increasing in the same ratio that our looms produce more linen and cotton cloth. But then the increase of knowledge runs in a parallel line with this increase of comforts, and the increase of knowledge requires an increase of books.

The use of cotton for clothing has become so general as to have an important influence upon the supply of rags. It has to a considerable extent superseded linen. When cotton cloth has been much worn, it is of little value for pulp, since the paper made from it will hardly bear its own weight. To remedy this, imported rags, which are supposed to be about 80 per cent. linen, are mixed with the domestic cotton rags, giving the paper a strength and firmness it would not otherwise have. The best qualities of writing and printing papers contain 30 to 50 per cent. of linen, which is entirely derived from abroad. The use of cotton clothing is, however, rapidly spreading all over the civilized world, and the effect of this is that the proportion of linen contained in the imported rags decreases from 5 to 10 per cent. every year. An ultimate resource is, however, new raw cotton, which, mixed with the worn rags of the same material, makes a beautiful paper. Some twenty years since, after the great revulsion of 1837, cotton was so cheap that large quantities were manufactured into paper. It is ordinarily too dear for that purpose. Some years since the project was started of importing the mummy wrappers from Egypt, to convert them into paper. Old Mehemet Ali, who was chief manufacturer in his own dominions, stopped the project, by forbidding the export and monopolizing that valuable material for his own mills. A curious thing that, that the clothing which swathed dead Egyptians, three to four thousand years since, should now be the medium of knowledge in this nineteenth century.

The quality of the paper depends greatly upon that of the linen worn in the country where it is made. Where that is coarse and brown, the rags and the paper made from them must be so too. The quality of the rags depends very much upon the state of civilization of the countries which produce them; the lower the state of civilization, the more coarse and filthy the rags. When the rags are received at the mill, they are sorted according to their respective

qualities; for if rags of different qualities were ground together at the same engine, the finest and best parts would be ground and carried off before the coarser were sufficiently reduced to make a pulp. In the sorting of rags intended for the manufacture of fine paper, hems and seams are kept apart, and coarse cloth separated from fine. Cloth made of tow should be separated from that made of linen; cloth of hemp from cloth of flax. Even the degree of wear should be attended to, for if rags comparatively new are mixed with those which are much worn, by the time the first are reduced to a good pulp, the others are so completely ground up as to pass through the hair strainers, thus occasioning not only loss of material but loss of beauty in the paper; for the smooth, velvet softness of some papers may be produced by the finer particles thus carried off. The pulp produced from imperfectly sorted rags has a cloudy appearance, in consequence of some parts being less reduced than others, and the paper made from it is also cloudy or thicker in some parts than in others, as is evident on holding a sheet up before the light. When it is necessary to mix different qualities of materials, the rags should be ground separately, and the various pulps mixed together afterward. The rag merchants sort rags into five qualities, known as Nos. 1, 2, 3, 4, and 5. No. 1, or *superfine*, consisting wholly of linen, is used for the finest writing papers. No. 5 is canvas, and may, after bleaching, be used for inferior printing papers. There is also *rag-bagging*, or the canvas sacks in which the rags are packed, also cotton colored rags of all colors, but the blue is usually sorted out for making blue paper. Common papers are made from rag-bagging and cotton rags. An operation sometimes required after unpacking the rags is to put them into a *duster*, which is a cylinder four feet in diameter and five feet long, covered with a wire net, and inclosed in a tight box to confine the dust. A quantity of rags being put into this cylinder, it is made to rotate rapidly on its axis, and thus a great deal of dust is shaken out, which might otherwise vitiate the air of the rag-cutting room. The sorting is done by women and children in a large room. The rags are sorted, according to their fineness, into the *superfine*, the *fine*, the *stitches* of the fine, the *middling*, the *seams* and *stitches* of the middling, and the *coarse*. These divisions are more or less observed at the present day. The very coarse parts are rejected, or laid aside for making white-brown paper.

The paper was formerly made into sheets by means of the *mould* and *deckle*. The *mould* was a square frame or shallow box of mahogany, covered at the top with wire cloth; it is an inch or an inch and a half wider than the sheet of paper intended to be made upon it. The wire cloth of the *mould* varies in fineness with that of the paper and the nature of the stuff; it consists of a number of parallel wires stretched across a frame very near together, and tied fast through holes in the sides; a few other stronger wires are also placed across at right angles to the former; they are a considerable distance apart, and are bound to the small wires at the points of intersection by means of fine wires. In several kinds of writing paper the marks of the wires are evident, from the paper being thinner in the parts where the pulp touches the wires. In what is called *wove* paper, there are no marks of the wires; these are avoided by weaving the wire in a loom into a wire cloth, which is stretched over the frame of a mould, and being turned down over the sides is fastened by fine wire.

The *water-mark* in paper is produced by wires bent into the shape of the required letter or device, and sewed to the surface of the mould; it has the effect of making the paper thinner in those places. The old makers employed water-marks of an eccentric kind. Those of Caxton and other early printers were an ox head and star, a collared dog's head, a crown, a shield, a jug, etc. A fool's cap and bells employed as a water-mark gave the name to foolscap paper; a postman's horn, such as was formerly in use, gave the name to post paper. Connected with the sizing of papers is the blueing, which is said to have originated in the suggestion of a paper maker's wife, who thought that the practice of improving the color of linen while passing through the wash, by means of a blue-bag, might also be advantageously applied to paper. A blue-bag was accordingly suspended in the vat, and the effect proved to be so satisfactory that it led to the introduction of the large and important class of blue writing paper. It was soon found that smalt gave a better color than common stone-blue, and smalt continued to be used for many years; but when artificial ultramarine came to be manufactured at a very low cost, and in a great variety of tints,

this beautiful color gradually superseded smalt in the manufacture of writing paper.

From 1820 to 1830, some efforts were made to introduce into the United States machinery from Europe. England and France were before us in its introduction. Several machines were sent out from England; some very imperfect, and the cost too great for our manufacture. The patronage then offered was no inducement to our own machinists to construct so expensive a machine until 1830, about which time Phelps & Spofford of Windham, Connecticut, made one which answered very well. Soon after, the country was supplied at a reasonable cost, and equal in quality to the best English. Not long afterward, Howe & Goddard, of Worcester, Massachusetts, commenced making the Fourdrinier—the shaking endless wire-web machine. The *cylinder* machine, more simple and less costly than the other, is in more general use; but the paper made on it is not equal in quality. Notwithstanding, it does very well for news, and the various purposes which a coarser article will answer for. These are made in various places throughout the United States. The interval from 1830 to 1840 was important for the vast improvements in the manufacture, by the application of this kind of machinery for that purpose; also, by the introduction of the use of chlorine in the form of gas, of chloride of lime, and the alkalies, lime and soda-ash, in bleaching, cleansing, and discharging the colors from calicoes, worn out sails, refuse tarred rope, hemp bagging, and cotton waste, the refuse of the cotton mills. These articles, which heretofore had been considered only applicable for the manufacture of coarse wrapping paper, have, through the application of this bleaching and cleansing process, entered largely into the composition of news and coarse printing papers, and consequently have risen in value 300 per cent. A few mills possess machinery and adopt a process by which they are prepared for the finest printing and letter paper. A beautiful paper is made of cast-off cable rope. Hemp bagging is an excellent material for giving strength, and is in great demand, especially for making the best news paper. The cost of making paper by machinery, compared with that of making it by the old method (by hand), not taking into account the interest on cost and repair of machinery, is about as one to eight. The present low price resulting from improved machinery and the cheap printing by steam power, has placed newspapers and books in the hands of all; and a great increase of production has followed within the last few years. The quantity now made might be nearly ascertained, if the deputy marshals could report the number of *engines* in operation: 300 pounds of paper would be the average daily produce of each engine—taking into consideration the loss of time and power from a deficiency of water in the summer season. There has been a greater proportional increase of mills in the middle and western states within the last ten years, than in the east. Ten years ago, 80 per cent. of the supplies for Philadelphia came from the east of the North River; at present there probably does not come 20 per cent. Formerly, a much greater quantity was sent west of the mountains, and large quantities of rags brought in return. In consequence of the greater number of mills in the west, particularly in Ohio, New Orleans is to some extent getting supplies there. Formerly, they all went from the Atlantic states.

CHAPTER II.

INVENTIONS—MANUFACTURE.

The slow and difficult process of moulding the separate sheets of paper by hand, has to a very great extent been superseded by the introduction and gradual improvement of the very beautiful machinery of Fourdrinier. By means of this machine, a process which, under the old hand system, occupied a couple of weeks, is now performed in a few minutes. Within this brief space of time, and the short distance of thirty or forty feet, a continuous stream of fluid pulp is made into paper, dried, polished, and cut up into separate sheets ready for use. The paper thus produced is moderate in price, and, for a large number of purposes, superior in quality to that which was formerly made by hand. In fact, the machine-made papers can be produced of unlimited dimensions; they are of uniform thickness; they can be fabricated at any season of the year; they do not require to be sorted, trimmed, and hung up in the drying-house—operations which formerly led to so much waste that about one sheet in every five was defective. The paper machine moves at the rate of from

twenty-five to forty feet per minute, so that scarcely *two minutes* are occupied in converting liquid pulp into finished paper, a result which, by the old process, occupied about *seven* or *eight days*. If the machine produce ten lineal yards of paper per minute, or six hundred yards per hour, this is equal to a mile of paper in three hours, or four miles per day of twelve hours. The paper is about fifty-four inches wide, and supposing three hundred machines to be at work on an average twelve hours a day, the aggregate length of web would be equal to 1,200 miles, and the area 3,000,000 square yards.

Paper is sent into market in various forms and sizes, according to the use for which it is intended. The following table contains the names and dimensions of various sheets of paper.

	Inches.
Foolscap	14 by 17
Crown	15 " 20
Folio post	16 " 21
Demy	17 " 22
Medium	19 " 24
Royal	20 " 25
Super-royal	22 " 27
Imperial	22 " 32
Medium and half	24 " 28½
Royal and half	25 " 29
Double Medium	24 " 38
Double super-royal	27 " 42
Double imperial	32 " 44

Many of the papers above enumerated are made by hand of the exact size indicated, but if made by the machine, the roll of paper has to be cut to the required dimensions. In order to do this with precision and expedition, various cutting machines have been contrived, in which the paper, as it comes from the manufacturing machine, is cut to any size required. Fine papers are, in many cases, hot-pressed and glazed. In hot-pressing, a number of stout cast iron plates are heated in an oven, and then put into a screw press in alternate layers, with highly glazed paste-boards, between which the paper is placed in open sheets; and the hard-polished surface of the pasteboards, aided by the heat and pressure, imparts that beautiful appearance which belongs to hot-pressed paper. A yet more smooth and elegant surface is produced by the process of glazing. The sheets of paper are placed separately between very smooth, clean, copper plates. These are then passed through rollers, which impart a pressure of twenty to thirty tons. After three or four such pressures the paper acquires a higher surface, and is then called glazed. The general introduction of steel pens has increased the demand for smooth papers, and has led to improvements in finishing them. As an improvement in the manufacture of paper sized by the machines now in use, it is proposed to conduct the web of paper, after it has been either partially or completely dried, through a trough of cold water, then to pass it through a pair of pressing rollers, and afterward to dry it on reels, or over hot cylinders. The paper which has been thus treated will be found to "bear" much better, and admit of erasures being made on its surface, and written over, without the ink running in the way it does when the paper is sized and dried in the usual manner. It has been found that when paper is dried, after sizing, by the drying machines in present use, the paper is very harsh, and until it stands for some time to get weather (as it is technically termed) great difficulty is experienced in glazing the paper. This inconvenience is proposed to be overcome by passing the paper partially round a hollow cylinder, through which a small stream of cold water is made to run. By this means the heat is carried off, and the paper is rendered more tractable, and brought to a proper state for undergoing the glazing operation.

We may describe the modern process of paper making, by detailing the operations as carried on in large mills. The visitor goes up to the second story, into a room some sixty by eighty feet, in which girls are engaged assorting the rags. Here are numerous bales of white rags, foreign and domestic. The imported are linen, the others cotton. In the same room these rags are cut by a machine, driven by power, which fits them for the subsequent processes. They are next sent into a rotary boiler of about two tuns capacity, into which steam is admitted, and the rags boiled. Next they are cast down on a floor in the first story, where they are put into cars, on which they are conveyed to the washing engines. Two engines are employed in washing, called rag engines. These engines play in tubs of an oval form, of large capacity, each containing perhaps 200 lbs. of rags. The impelling power, steam or water, causes the revolution of a roller, set with knives or bars of cast steel inserted in it longitudinally. This roller is suspended on what is called a *lighter*, by which it may be raised or lowered at pleasure upon a plate, consisting of bars of

steel, set up edgewise. Passing now between this and the plate, the rags are reduced to fibre. A stream of pure water is then conveyed into the rag engine, and, by means of a cylinder covered with gauze wire, the dirty water is passed off. This cylinder, called a patent washer, is octagonal in shape, some thirty inches in length, revolving in the engine, and having buckets within it, corresponding with the sides of the washer. By this process the rags are washed perfectly clean in from three to six hours.

The bleaching process is performed by the insertion into this engine of a strong solution of the chloride of lime and some acid, to cause a reaction. The pulp is then emptied into large cisterns, covered with the bleach liquor it contains, where it is allowed to remain from twelve to twenty-four hours to bleach. It is then drained, put into the beating engine, and reduced to a pulp, the consistency of milk, which it much resembles. This pulp is emptied into a large cistern, in a vault beneath, and kept in motion by means of an agitator revolving in it. It is then raised by a lifting pump into a small cistern, from which it is drawn off by a cock—which is opened more or less, according to the thickness of the paper intended to be made—on to a strainer, which removes the knots, sand, or hard substances that may damage the paper, and then flows upon a leathern apron, which conducts it to an endless wire cloth, over which the web of paper is formed. This wire cloth is kept constantly vibrating, which both facilitates the escape of water and the felting together of the fibres of the pulp. The wire cloth, with the pulp upon it—the edges being protected by deckle-straps—passes on until it comes to a couple of *wet-press* cylinders, as they are called, the lower of which is of metal, but covered with a jacket of felting or flannel; the upper one is of wood, made hollow, and covered first with mahogany, and then with flannel. These cylinders give the gauze with the pulp upon it a slight pressure, which is repeated upon a second pair of wet-press rolls similar to the first. The paper is then led upon an endless felt or blanket, which travels at exactly the same rate as the wire cloth, while the latter passes under the cylinders, and proceeds to take up a new supply of pulp. The endless felt conveys the paper, still in a very wet state, between cast iron cylinders, where it undergoes a severe pressure, which rids it of much of the remaining water, and then between a second pair of press-rollers, which remove the mark of the felt from the under surface; and finally it is passed over the surface of cylinders heated by steam, and when it has passed over about thirty lineal feet of heated surface, it is wound upon a reel ready for cutting. Forty years ago three men could by hand manufacture 4,000 sheets in a day. The same number now by the aid of machinery will make 60,000.

From the time of the Revolution the quantity of paper imported has been gradually decreasing; and before the revision of the tariff in 1846, had dwindled to perhaps not more than 2 per cent. of the amount consumed, with the exception of wall papers, of which large quantities were imported, and still continue to be, from France. Since 1846, there has been an increase of cheap French letter paper, but the amount is small compared with the whole amount of letter paper consumed, probably not more than 3 per cent. There is also a small quantity of ledger and letter paper brought from England, but as the American is quite equal in quality, the importation is gradually diminishing. Within the last few years great ingenuity has been exercised, both in England and the United States, in trying to make a paper by machinery to resemble the old-fashioned hand-made *laid* paper (yet preferred by many). To the eye it is a pretty good imitation, but lacks the toughness, firmness, and surface of the hand-made. By an experienced judge the difference is easily discovered. Notwithstanding, large quantities have been used under the supposition that they were hand-made. The reduced price of machine paper has forced almost all manufacturers to abandon the old method. There were a few years since only two mills in operation in the United States in which it was made by hand—one in Massachusetts and one in Pennsylvania. There is a limited quantity of peculiar kinds, that can be better made by hand than on a machine, such as band-note, laid letter, deed parchments, and such as are used for documents that are much handled, and require great strength and durability. Within the last few years some improvement has been made in the finish of writing and printing papers, by the introduction of iron and paper calenders for the purpose of giving a smooth surface. The finish of American papers is now equal to any in the world.

The quantity of paper required for the newspaper service of the country is probably 150,000,000 lbs. per annum, which would allow a circulation of 750,000,000 sheets. There would remain 250,000,000 lbs. of paper for the service of the book trade, and the trade and publications of the religious societies.

The use of paper-hangings, which has become so common in the past ten years, superseding hard finish and painted walls for city dwellings, absorbs a large amount of paper. In Philadelphia, which has been the leading place for the manufacture of paper-hangings until more recently, when the business has been carried on in New York and Boston, the consumption of paper for hangings has been yearly 1,500 tons, or 3,000,000 lbs. The paper used for this purpose is heavy, and comes from the mill in rolls 1,200 yards long, and from 20 to 35 inches wide. It costs from 9 to 14 cents per pound. In the preparation of this paper the pattern is first carefully drawn from original designs, and then printed. The outlines of the various tints are made each upon a separate block, made of pear-tree mounted with pine. The color is contained in sieves, and the blocks thus applied to these are laid upon the paper, following each other upon the guide-marks left by the previous impressions. It is stated that a paper-hanging exhibited at the World's Fair, and representing a chase in a forest with birds and animals, was perfected by the application of 12,000 blocks.

In making what is called flock (shearings of broadcloth) paper, the pattern is printed in size and varnished; the wool then being sifted on the varnished pattern, adheres to it.

The census of 1850 gave the localities of the paper mills and their comparative importance as follows:—

MANUFACTORIES OF THE UNITED STATES.

States and Territories.	No. of Establishments.	Capital.	Cost of raw material.	Male hands.	Female hands.	Cost of labor.	Value of product.
Alabama	1	$10,000	$8,000	6	4	$1,776	$18,000
Connecticut	43	964,100	968,709	507	429	220,104	1,726,685
Delaware	3	106,200	90,674	28	16	11,256	119,240
Georgia	2	62,000	10,550	16	13	4,188	26,000
Illinois	1	26,943	7,800	13	5	5,400	39,600
Indiana	5	64,000	43,600	42	32	15,600	94,500
Kentucky	3	92,000	87,250	51	26	18,072	135,600
Maine	6	117,000	81,700	68	47	28,188	179,520
Maryland	25	134,300	118,668	117	69	28,812	234,365
Massachusetts	77	1,815,900	1,507,588	831	863	374,916	2,601,628
Michigan	1	3,000	3,550	4	6	2,016	15,000
New Hampshire	15	144,500	90,134	97	36	30,120	205,010
New Jersey	32	782,500	535,570	292	215	120,384	888,475
New York	106	1,318,633	844,208	823	444	271,884	1,634,579
North Carolina	2	27,000	4,905	6	7	1,728	7,400
Ohio	25	520,800	303,676	348	221	139,776	701,036
Pennsylvania	61	683,413	579,094	344	281	123,264	1,036,655
Rhode Island	3	44,000	24,290	23	..	7,560	46,000
South Carolina	2	30,000	9,500	14	78	3,264	23,200
Tennessee	7	40,475	21,125	28	16	8,646	40,106
Vermont	15	152,200	131,688	100	90	39,252	252,370
Virginia	7	113,900	73,650	70	48	39,312	147,208
Wisconsin	1	8,000	10,000	7	4	2,280	15,000
Total	443	7,260,866	5,553,929	3,836	2,950	1,497,792	10,187,177

HAND CARDING.

WOOLLEN MANUFACTURES.

CHAPTER I.

WOOLLEN MANUFACTURES — CARDING — WEAVING—FELTING.

THE manufacture of woollen, or any other goods, having been prohibited in the colonies under that harsh principle which prompted the Earl of Chatham to exclaim that the "colonists had no right to manufacture so much as a horse-shoe nail," much progress could not have been expected. Nevertheless, progress was made, since the home manufacture of woollen cloth became very general. The people spun and wove their own cloth, and the merchant found little sale for the imported article. The oppressions of the home government were continued, until finally, in 1765, a society was started in New York with great zeal, not only repudiating all foreign goods, but taking measures to encourage the home manufacture of cloth from sheeps' wool, and from all other materials. This was very popular; and an agreement was extensively entered into, in order to encourage the growth of wool, to eat no mutton or lamb, and to purchase no meat of any butcher who should kill a sheep or lamb. The economist of the present day will smile at such a mode of encouraging the farmer to keep sheep, viz.: by cutting off his market for the mutton. Nevertheless, it showed zeal. Manufactures are not, however, to be established by resolution. For their development there are necessary, 1st, the supply of skilled labor; 2d, the material for its use; 3d, the capital to employ it; and 4th, the demand for the goods. This latter existed to a considerable extent, on certain conditions, among which was, that it should come within the means of the consumers. There does not appear to have been much scarcity of wool, since home-made goods were generally used. There was an absence, however, of capital, and of that skilled labor which is always the result of extensive experience in the same employment. There came great numbers of artisans from Europe, and it was stated that 30,000 weavers left Ulster in 1774. The war came, peace succeeded, and the new government was formed in 1791; on which occasion, Alexander Hamilton, Secretary of the Treasury, made his famous report on manufactures. He stated, that of woollen goods, hats only had reached maturity, and supplied the demand. At Hartford, a mill for cloths and cassimeres was in operation, and produced excellent wares, under the circumstances; but he remarked, that "it was doubtful if American wool was fit for fine cloths." The quality of wool grown in the country must, since then, have changed very much, since the American wool is used entirely for the fine goods, and the imported wools only are used for carpets and coarse manufactures. The manufacture of cloths did not progress rapidly, since we find that, in 1810, according to the report of the Treasury department, ordered by Congress, the manufacture of wool was still mostly in families. The progress of the manufacture, according to that report, has been as follows:—

	1810.	1820.	1830.	1840.	1850.
Woollen manufacture,	$25,608,788	4,413,068	14,528,166	20,696,999	43,207,545

This value, in 1810, was nearly all in families, and the figures subsequently are the product of regular manufactures as the business progressed. The family manufacture was necessarily of a rude description. The wool, being washed, was carded between two cards held in the hands of the operator, who continued to card until the wool was formed into a long roll, which was then spun upon the single spindle, driven by the wheel that the busy hand of the housewife kept in motion. There are many still living who

were employed in sticking the teeth for those cards, and in tending the wheel. The cloth, woven also by hand, was subsequently sent to mill to be fulled, and dyed, and dressed; which was the first regular business branch of the manufacture. The dyeing was rather an imperfect process. The operator did not then understand the art of fixing colors. Daniel Webster somewhere relates his misfortune, when, dressed up in a new suit of home-spun blue, he accompanied his father on the way to a new school, and, being overtaken by a shower, had the color washed from his new coat into his shirt. With the lapse of time dyeing became better understood. Not many years have elapsed, however, since the distinctive mark of American cloth was, that it wore "white on the edges;" in other words, its color was not fast. With the introduction of machinery, and the improved condition of the people, home manufactures necessarily gave way to machine work. Other occupations paid the time of the farmer better, and the use of machines gradually made a market for the raw wool, at a price which, compared with falling prices of the cloth, would give the wool-grower his cloth without labor. This we may illustrate by extreme figures. Suppose, there being no factories, wool is worth 10 cts. per lb., and cloth imported, $2 per yard, a pound of wool will make two yards, or $4; if not as good cloth, at least good enough. The farmer, by turning his wool into cloth, makes a large saving. Soon, however, machine labor sinks cloth to 50 cts. per yard, and raises wool to 60 cts. The farmer can now no longer afford to make his own cloth, but his wool trade has become profitable. Thus, machine goods supplant hand goods. In this line, the inventions have been very remarkable.

In 1797, Asa Whittemore, of Massachusetts, invented a machine for making cards. Instead of sticking them by hand, as before, a strip of leather, by passing between a cylinder and a scraper, becomes of equal thickness. This strip of leather, in passing through the machine, is stuck full of teeth, that are also made from steel wire by the machine at the same time. The ingenuity of this machine was such, that the famous John Randolph, on inspecting it, exclaimed, that "it operated as if it had a soul!" There have been 100 patents since issued for improvements in this machine. The hand cards were then supplanted by the carding machine. This has a drum of about 3 ft. diameter, and as many long, covered with the cards. Smaller cylinders, also covered with cards, are placed so as to revolve against the circumference of the cylinder, and in the contrary direction. There is a feed apron, on which the wool is laid, and, being drawn in between two rollers, is caught by the cards of the revolving drum, and combed out between it and the smaller cylinders. The wool is thus spread on the surface of all, and is finally taken up by the "doffer," or a cylinder in front of the main drum; from this it flows in a broad, thin, gauzy fleece, which passes through a funnel, and in so doing is contracted into a ribbon, or sliver, which is delivered into a can, ready for the "drawing frame." Long wools and short wools are subjected to different treatment in this stage of the manufacture. The long wools are sometimes called combing wools, in consequence.

In the manufacture of worsted, the long staple is used mostly, because a smooth, fine yarn is required, not much liable to full, or shrink, or curl. In order to form such a thread, the first object is to lay or stretch the fibres into lines, as parallel as possible. If it were possible to procure a single fibre of wool of a length sufficient to weave like a fibre of silk, the beauty and finish of the fabric would be as nearly perfect as could be expected. As that, however, is not possible, the object of the manufacturer is to draw out the fibres into parallel lines, in order that they may twist into a thread as fine and smooth as can be obtained. The old mode of doing this was by hand. When the wool has been washed with lye, or soap and water, and dried, it passes into a machine called the "picker," tended by a boy, who lays the wool as evenly as he can upon the feed apron, which carries the wool between rollers, when it is caught by revolving teeth, torn asunder, and scattered in the air. The fibres are thus cleared and straightened to some extent. They were then taken to the comber, who, in a close room, employed combs with long, heated teeth. The workman oiled the wool, and combed it with these heated instruments, until it became suitable, when it was arranged in "slivers." This was a very laborious and unhealthy task, and many machines have been invented to supersede the hand labor. There are many of them very ingenious, and have advanced the stage of the manufacturer in an eminent de-

gree. When the "slivers" are thus prepared, they are carried to the "breaking machine." There the first sliver is placed upon an apron, which carries it between two rollers, that seize and draw it forward, and it passes from them through other sets of rollers, which move three times as fast. As a consequence, the sliver is drawn out to three times its original length. When it has half passed into the first set of rollers, the end of another sliver is laid upon it, passing thence with it, and becoming incorporated with it in the drawing. All the slivers thus become incorporated in one of three times the aggregate length of all the original slivers, and it is coiled in a can. Three of these cans are carried to the "drawing frame," which has five sets of rollers, operating in the same manner as the breaking frame. As fast as the sliver comes through one set of rollers, it coils into a can, and the slivers of three cans are then united, and pass through another set of rollers. These drawings thus take place 1,500 times with some wool, and the process reduces the sliver to one-fourth its original bulk. There are many variations of the detail of drawing by different machines, but the result is the same. After the drawing is finished, a pound of the sliver is taken and measured, in order to test the accuracy of the drawing. This done, the sliver is passed to the "roving" frame, where two slivers are drawn, as before, into a "roving," which has now become so attenuated, that it must have a twist to hold it together. This twist is imparted to it as it is wound upon spindles, of which the frame contains a great many. The bobbins from the roving frame spindles are then carried to the spinning frame. They are placed upon skewers, and the roving proceeds from them between rollers, of which there are three sets: the first pair turns slowly, the middle twice as fast as the first, and the third from twelve to seventeen times as fast as the first pair. The spindles that receive the thread from the rollers must turn very fast to give the required twist to the thread. The hardest thread is tammy warp, and, when this is of size of twenty-four hanks to the pound, the twist is ten turns to an inch. The least twist is given to thread for fine hose, and it is then five to the inch. The threads are then reeled. The bobbins are placed in a row upon wires, before a long horizontal reel, which is exactly a yard in circumference. When this has revolved eighty times, it rings a bell. It is then stopped, and a thread passed round the eighty turns of each thread. The reel then proceeds. Each of these eighty turns is called a ley; seven such are a "hank;" which is, consequently, 560 yards. When this quantity is reeled, the ends of the threads are tied together, and each hank is weighed by a machine, which denotes the number of hanks to a pound, and this is the number of the yarn: thus, No. 24 means that twenty-four hanks of 560 yards, each will weigh 1 lb. A hank of cotton measures 840 yards.

Short wool, for the cloth manufacture, resembles cotton in some respects. The wool being oiled and "picked," is passed through the carding machine, whence it proceeds through the drawing process, as with the long staple, until it assumes the form of yarn for the weaver.

In woollen cloths, cassimeres, broad cloths, narrow cloths, etc., all wool is used: that is, both warp and weft are wool, but the wool is combined with many other articles, according to the dearness of each. The cotton warp is used in satinets; and in most descriptions of dress goods there is a combination of wool with silk or cotton. If these articles are very high, more wool is used; and the reverse, if wool is high, and cotton is cheap, more cotton is introduced into the fabric. There are also a great variety of styles and patterns constantly produced, to attract attention.

The weaving process on the improved power-looms has been greatly facilitated of late years, and the labor has been diminished. Thus, formerly, one person was required to tend one loom, at a certain speed; but, by various improvements, one person may now tend four. In large factories, great numbers of looms are placed in one room, and, as the cloth-rolls become full, they are placed upon a little rail-car, which carries them off to the dyeing and finishing department.

The woven cloth is carried to the fulling-mill, to have the oil applied in spinning, and other greasy matters removed, and, by a partial felting, to give the fabric more compactness. The first process is to scour the cloth. This is done by placing it in troughs, so arranged as to contain the liquids—stale urine and hog's dung, then urine alone, and to be followed by fullers' earth and urine. Heavy oaken mallets, or pounders, slide

down with force into one end of the trough, and mash, or roll over the cloths. The pounders are lifted by wooden cams, kept in motion by horse-power for many hours. In this process the oil is detached from the wool, the urine is absorbed by the earth, and both washed off by the water. When this is complete, soap is applied liberally, and the pounding continued, to full the cloth. Instead of soap, in some cases steam is applied, and the pounders made of iron. The process of fulling is also effected without pounders, the cloth being pushed, or squeezed, through a long trough. After the fulling, the soap is washed out, and the cloth is ready for teasling. To full a piece of broadcloth requires sixty to sixty-five hours, and 11lbs. of soap are usually applied. In the process, the cloth will shrink in length from fifty-four to forty yards, and from twelve quarters wide to seven quarters.

When cloth is returned from the fulling-mill, it is stretched upon the tenter frame, and left to dry in the open air. As cloth in the fulling-mill shrinks nearly one-half, it must be woven nearly double its intended breadth. Superfine six-quarter broadcloths are therefore woven twelve quarters wide.

The cloth is minutely examined, when dry, in every part, freed from knots and uneven threads, and repaired, by sewing any little rents, or inserting sound yarns in the place of defective ones.

In order to raise up the loose filaments of woollen yarn into a nap upon one of the surfaces of the cloth, it is scratched with the heads of the teasel plant, or with teasling cards made of wire. In large factories the operation is performed in the gig-mill, which is a cylinder covered all over with teasles, and made to revolve rapidly, while the cloth is drawn over it. This operation requires attention, lest the goods become tender. Indeed, every branch of the wool manufacture requires the supervision of a practical man. If a piece of cloth comes from the press damaged, or inferior, he must be able himself to discover where the fault lies, without taking any other man's word for it; if the wool is not properly cleaned and dyed, the dyer must be called to account, not the carder, or the weaver; and if, through the carelessness of the shearer or gigger, the goods are made tender, they must answer for it, not the spinner. Therefore, the manager of a woollen establishment must be a thorough practical manufacturer, conversant with all the branches of his business, and able to assume and maintain the responsibility of each and every one. This individuality of the manufacturer is well divided among the different branches of the manufacture in England, where the business has grown up in the hands of practical men; but in this country, where manufacturing was, as it were, improvised on the formation of the government, it came, necessarily, under the control of corporations, where the supervising power could not be so well exercised as where each branch is produced by an individual on his own responsibility, and to meet the consequences of defect himself. In a corporation, many of the appointments are independent of the general direction, and the resulting defects in fabrics are placed to the account of the wrong party, or not fixed upon any.

The art of dyeing and printing fabrics is one of the most progressive connected with manufacturing. The materials of human clothing are mostly from silk and wool, of animal origin, and cotton and flax, of vegetable origin. These two classes differ in the facility with which they imbibe coloring matter. The animal fibre takes much more brilliant shades than the vegetable, and the color may be applied to either class in the raw state, in the spun yarn, or in the fabric: hence, great diversity in the processes. The coloring matters are themselves of the most various origins—animal, vegetable, and mineral—and their substances, brought together, act upon each other, and produce the most intricate changes. The leading vegetable colors are yellow, brown, and red; blue is derived only from litmus and indigo; black is afforded by nutgalls, sumach, and cashew nut. These are generally obtained by water; but some of the substances require either alcohol or some of the fixed oils. From the animal kingdom come, from the bodies of the cochineal and kermes insects, the brilliant scarlet and crimson dyes. The ancient dye, called Tyrian purple, was long supposed to be lost; but a French chemist has lately discovered it. Hoofs, horns, etc., give Prussian blue. Many brilliant colors are derived from the salts of various metals. The same metal is caused to give various colors. Iron gives that buff known as nankeen; it gives various shades of blue, and is made to yield black, slate color, and other shades. Chrome, and lead salts, give an interesting variety of colors. The materials to be dyed, of what-

ever nature, are seldom found to have such an affinity for the coloring that they will retain them. They will soon wash out, unless a remedy is applied. Chemistry discovered this in certain substances that will fix themselves permanently upon the fibre, and then, by uniting chemically with the color, "fix" that permanently also. These applications are called "mordants," from the Latin, *mordeo*, because they were thought to bite into the fibre. It is sometimes the case that, in thus combining with the color, the mordant will modify or alter its tone, and those having this effect, are sometimes called "alterants."

Thus, if a decoction of madder be applied directly to cloth, it gives a dirty red color, that will not remain. If the cloth is first prepared with acetate of alumina, the color will not only become entirely fast, but will assume a fine red hue, which will resist the action of air, light, and water. If, instead of the alumina, oxide of iron is used as a mordant, a purple color will be obtained. In dyeing with cochineal, if crimson is required, alumina is used for a mordant; if oxide of iron is used, the color will be black. It follows, that mixing mordants will multiply shades, and the variations of proportions and strength of solution gives a wide field for the production of effects. It sometimes is the case, that two solutions, neither of which will give any color at all to the fabric, will impart a fast color by following each other in the application. Thus, a solution of nitrate of potash gives no color to cloth, and may be washed out; the same is true of bichromate of potash; but if one of these is applied after the cloth has received the other, a fast yellow is obtained. In the process of mandarining, an acid is made to act directly upon the fibre of the wool. In a large factory, the dye stuffs are ground and mixed in an appropriate room. The infusions are made in tubs or vats, some in cold water, and others in boiling water. Some of the dyes are introduced in the shape of a coarse powder, and others in bags, through which the color oozes. The cloth is first prepared by thorough cleansing, in order to remove all extraneous matters that may be attached to the fibre. When this is completed, the mordant is applied by soaking the cloth in appropriate solutions. It is then hung up to dry in long folds, if intended for printing, as in the case of muslin-delaines, a fabric in which the American manufacturer has come to surpass the imported article, and to monopolize the market.

The art of printing goods may be said to have been created in the last fifty years. As practised in the early part of the century, it was comparatively rude. The figures to be impressed upon the cloth were engraved upon a square block of wood, and the color being applied to this, it was impressed upon the cloth, which was then drawn forward, and a new application of the block made. This was the style of printing practised originally by Robert Peel, grandfather of the late prime minister of England, and founder of that family. An improvement was then made by engraving the pattern upon a copper cylinder, and by passing the cloth over this, the work was done with more precision and continuity. This was costly, however; and one such cylinder laboriously engraved, would print only 1,500 pieces of cloth. Perkins, of Newburyport, Massachusetts, then invented the die. This is a small steel roller, on which the figure is engraved, and made exceedingly hard. From this, the figure is conveyed to a soft steel roller by pressure. From this last the design is impressed upon a copper roller by pressure. This last prints the cloth. In this manner, the design on the steel die, once engraved, may be multiplied to any number. The original block-printing would take but one color. Numbers of improvements were made to increase the number of colors that might be printed. This is now done by engraving the dies and rollers with portions of the designs that are to take different colors. The rollers are placed upon the printing machine in such a manner, that the cloth passes up slowly over the large drum of the machine. They each, in succession, impress it with the design and color with which they are fed. Almost any number of colors may thus be printed. The style and quality of ladies' dress goods of wool, have thus made rapid strides in the last few years.

The faculty of felting possessed by the wool, arises from the barbs upon each fibre, like those that are to be seen on each fibre of a feather, locking into each other. The process of rubbing in hot water causes those in the wool to become more closely interlocked, until the whole becomes a compact mass.

The making of hats of wool was a large business in the New England colonies early in the 18th century—so much so, as to draw upon them the interference of the government for

the suppression of the business. It continued, however, locally, and was, in 1791, mentioned by the Secretary of the Treasury as one of the most successful. The manufacturing process was mostly the same, although the form of the hat underwent many changes, from the "cocked" to the "stove-pipe," and latterly to "Wide Awake," "Kossuth," and other styles. The wool—mostly lambs or short wool—was washed in urine to remove all grease that prevented felting. The wool then, being dried, was "bowed." This was performed by the operative, who laid about 3 oz. of wool upon a board, and then, holding in his left hand a bow with a stiff string, he vibrated the string in such a manner as to strike the wool, and cause it to fly out clear and loose. When quite clear, it was formed by hand into a cone form nearly three times as large as the proposed hat body. To keep the light wool together, it was placed between two cloths. It was then immersed in water, and continually rolled in different directions upon a short round stick held in the hands of the operator. This operation caused the hat to felt or shrink into the proper size and shape. Being then in the sugar-loaf form, it was stretched upon the hat block that gave it its shape, and the manufacture proceeded with, until, napped with fur and trimmed, it was ready for sale. About 30 years since, machines for forming the bodies were introduced, and these soon supplanted the old hand system. The wool was washed with soft soap as a substitute for urine, the lye of the soap being equally efficacious in removing the grease. When dry and clean, the wool was passed through the "picker," made with a cylinder covered with long teeth. As this revolved with great velocity, it took from a pair of rollers the wool, separated it, straightening the fibres, and cleaning it of dust at the same time. This wool was then passed through the breaker, or carding machine, as in preparation for spinning; but as the broad fleece comes off the doffer, instead of being drawn into a ribbon, it is received upon a pair of light wood cones, placed with their bases together. To these a vibratory motion is given at the same time that they revolve. The result is, that the fleece of wool winds over them in contrary directions, until they appear like a large cocoon. When about 3 oz. are wound upon the cones, the boy who tends cuts them apart with shears, and by a rapid movement removes the woolly cap from the cone, which instantly resumes its motion. These caps, so removed, are perfectly formed "bodies," ready to be felted in the usual manner. The regularity and rapidity of the formation enables a "body" to be formed with much less wool than by the hand system. Instead of 3 to 4 ozs. for a hat, a perfect body was now formed 1 oz. weight. This process of the wool manufacture grew rapidly, until a machine was invented to form hat bodies of fur. The difficulty in that respect had been that the fur could not be carded into a fleece like the wool. A machine was then invented, by which the air was exhausted under a fine wire gauze, and the fur flying was drawn upon this and partly felted into a ribbon, which was wound upon cones for the hat bodies. The next process was to form the cone itself full of holes, and, by exhausting the air, the fur is caused to settle upon it evenly, in weight sufficient for a body. These fur hats caused those of wool to rank second.

The felting qualities of wool have, however, caused it to be used for many other purposes, such as piano-covers, drugget, and for the manufacture of cloth without weaving. This is called beaver cloth, and is difficult to detect, by the eye, from woven cloth. Several manufactories of this description are in operation in Connecticut. The wool being worked and "picked," is carded in a machine which is double the width of the ordinary one, in order to deliver a fleece or web six feet wide instead of three. This "web" is, as it is delivered by the machine, carried out, in a horizontal direction, 21 feet, and so doubled in folds until it gets a proper thickness for felting. Inasmuch as that the process of felting causes a web to contract more in breadth than in length, it becomes necessary, to give the cloth a proper consistency, that the webs should cross. To do this two machines are placed at right angles with each other, and as the web of one is extended, that of the other crosses it. When the proper thickness is thus attained, the whole is rolled upon a beam, and transferred to the felting table. Here a number of cloths are laid together upon an endless apron, the movement of which carries them forward over an iron plate, perforated with holes, through which steam ascends, and thoroughly heats and saturates the cloths, which proceed under a platen, to which steam power imparts a rapid vibratory mo-

tion, which felts the cloth. When this is completed, the cloth is dyed of the requisite color, and then subjected to the fulling and teasling process, like a woven cloth. For those heavy coat cloths that are in the style called Petershams, another process is substituted. It consists in passing the cloth under a sort of press, of which the lower side, on which the cloth rests, is stationary, and the upper, being covered with sand, receives a rapid, rotatory, vibratory motion, which rolls up the nap into those little knots that are the distinctive feature of Petersham. The nature of these cloths permits of giving them two colors. Thus a dark and a drab color may be felted together to form one cloth, of which the inside is of a different color from the outside. These cloths are used to some extent by the clothiers, but their durability is said not to be such as to recommend them.

Of all people, the American shows the most remarkable inclination for good carpets. It seems to be impossible for him to walk comfortably through life without a carpet under his feet. Every man who occupies a few square feet of house-room must have the brick or the boards protected from his tread by so much carpeting. Here carpeting appears in a thousand places where, in other parts of the world, it is never seen. The English shopkeeper thinks the bare boards good enough for the reception of his customers, and seldom does the merchant think of adding to the elegance of his counting-room by laying down a square of Brussels. Only those churches devoted to the service of the more aristocratic worshippers, are furnished with the comforts of Kidderminster—the bare wood, or bricks, or stone, being considered more consonant with "the self-denying duties of the sanctuary." Widely different is it with the well-to-do American. He believes in enjoying life; and considering that carpets contribute to life's enjoyment, he does not hesitate to spread every place where he is accustomed to tread with a due quantity of three-ply, or tapestry, or Brussels, or Turkey. Yet, withal, the quantities imported are apparently inadequate to this general demand. The number of yards, of all descriptions, imported, is about 1,500,000 per annum—a quantity that might suffice for 15,000 houses; but in 1850, according to the census, there were 3,362,000 dwellings in the Union. It follows, that by far the largest portion of carpets are furnished by home manufacture. The carpets most in use in this country are known as "rag carpets," as ingrain, three-ply, Venetian, tapestries, Brussels, velvets, Wilton. The Turkey, Axminster, and Persian carpets are used but little, and manufactured not at all. The ingrain carpet is made with two sets of worsted warp, and two sets of woollen weft. It consists of two distinct webs, incorporated into each other by the warp threads passing from one to the other to bring the required colors to the surface. Each web is, however, a cloth of itself, which, if separated by cutting from the other, would present a coarse surface, like baize. Two colors only are used with effect in this kind of carpet. The three-ply is similar, but produced by three webs, making a thicker carpet, with a greater number of colors. The pattern in this does not appear in opposite colors, as in the two-ply. This fabric was long thought not adapted to power looms, but in 1839, Mr. Bigelow, of Lowell, improved the matter, so that weavers, who were then making 8 yards per day by hand, could make 12 yards per day by power. This plan has since been so improved, that power looms are now wholly used, with such economy of labor as greatly to reduce the cost of carpets. The hand weaver could always tighten the weft thread, if he found it too loose to make the selvage regular, and if he saw that the weft thread was too irregular to make the figure a just proportion, he imparted more or less force in beating it up. The judgment and skill of the weaver was thus a great element in the production of the goods. Mr. Bigelow, in his first loom, contrived to take up the woven cloth by an unerring motion, the same amount for every beat of the lathe. His next step was to regulate the tension of the threads, so as to keep the selvage smooth, and the figure regular. In this he succeeded so as to bring the two-ply loom to 27 yards per day, and the three-ply loom to 18 yards. His method of producing figures that will match was patented in 1845. The same machine was found to be applicable to Brussels and tapestry carpets, the weaving of which by power was before thought to be impracticable. They were made at the rate of 4 yards per day by hand. This has been increased to 20 yards per day by the new process. The figures of the carpets are also made so as to match perfectly, and surpass the best carpets made in any other part of the world.

These looms are used in factories built for them in Lowell and Clinton, Massachusetts; Thompsonville and Tariffville, Connecticut; a large factory is in operation in New York, and Philadelphia and other cities have lately established them. The Brussels carpet takes its name from the capital of Belgium, whence it was introduced into England in the last century. It is made upon a ground of linen weft, which is concealed by the worsted threads that interlace and cover it. The threads are generally of five different colors. In weaving, these run the length of the web, and are so managed that all those required by the pattern are brought up together across the line of the carpet. Before they are let down, a wooden instrument called a sword is passed through, to hold up the threads. This is replaced by a wound wire, which being at last removed, leaves a row of loops across the carpet. In a yard there are sometimes 320 successive lifts of the sets of colors required, each of which forms a row of loops. Four colors must always lie beneath the 5th, which appears on the surface, and thus the carpet is thick and heavy. The Wilton carpet differs from the Brussels in that the loops are cut before the wire is removed. A groove runs in the wire to receive the edge of the cutting knife. The soft ends of the cut loops give the carpet its velvet appearance. In Imperial Brussels, the loops of the figures only are cut. Here a new invention was brought into use to make "tapestry and velvet pile." This is a combination of the arts of printing and weaving. The principle is this: if a rose-bud occurs a thousand times in the length of a web, at 4 feet apart, the block printer must apply his block a thousand times to print the bud. By the new process the thread is wound a thousand times round a cylinder 4 feet in circumference, and a turning wheel, charged with color, passes across the coil. The thread unwound is found to be marked in a thousand places exactly where it is wanted. The threads are thus all parti-colored, and singly show no regular figure; but when arranged in the proper order for the weaver's beam, the figures come into view much elongated. Sometimes 18 feet of warp will be gathered into 4 feet of cloth, in order to secure the due proportion of the intended object. By this system the number of colors, that could not exceed 6 or 7 by the old plan, is now increased to 20 or 30, or any number; and instead of a change of blocks for every pattern, the same blocks serve for all patterns.

The wool used for carpets is imported from South America and the East Indies. Of that obtained from South America, the best is the Cordova, which is worth here 22½ and 23 cents per lb., and next in grade to it ranks the Buenos Ayres, worth 13 and 14 cents per lb. The East India wools all rank still lower, and are generally of a dark color. It may be interesting to follow the wool in its passage through the various processes which transform it from its hard, dirty, and oily mass, lying in bales, to the brilliant velvety pile worthy the foot of Flora McFlimsey. The material passes in the usual way; from the wash to the combing machines, which separate the long from the short fibres. The long are passed through rollers, and assume a form entitled a "sliver," which is allowed to fall into a hollow cylinder set for the purpose, while the short fibres disappear in a mysterious-looking box at one side of the room. These slivers are then passed through a drawing frame, twenty or more of them united, and drawn out so as to equalize the thread; eight or ten of these threads are again subjected to the drawing process and reduced to one, which operation is repeated as often as is necessary to produce uniformity. These long fibres, so carefully put through this process, are intended to form the warp of the carpets, while the short fibres are used for the "woof" or "filling." In the spinning-room, both staples of wool come together to be spun on the long, clashing, clattering "spinning jacks," twelve in number, some of them spinning 256 and others 308 threads at once. When it leaves the "jacks" it is in the form of coarse yarn, tightly rolled on large spools, from which it is wound into skeins and is ready for the dye house. By a curious system of folding, of a recent American invention, part of the yarn skeins are, after being scoured (a process applied to all yarns to free them from their natural oil), subjected to a parti-colored dyeing—and thus the same skein, or frame of skeins, may sometimes bear half a dozen different colors. These parti-colored yarns are used for warp. Other bundles of yarn are submerged in rolling, steaming floods of colored liquids of every hue. That portion intended to be used white, is bleached by means of sulphur in houses erected for the purpose on the river bank. From the dye-

ing-room, the yarn is conveyed to the drying-room, immediately over the engine boilers, and after it has become thoroughly dried, is conveyed to the winding-room, where winding machines, worked by girls, are at work, filling spools and bobbins from the skeins; and no sooner are the spools filled than they are unfilled by the warping machines, five of which are constantly in operation. The threads are here wound upon the large cylinders for the printers, and each filling of this great cylinder makes but a single thread in the warp of a single pattern, so that for a piece having 208 threads in its width, the cylinder must be filled and carefully printed a corresponding number of times. These monster skeins, after being printed, sometimes with 100 or more shades of colors, each laid on in straight lines by a small printing roller, travelling across beneath the large cylinder, are packed at full length in rice chaff, and having been placed in boxes on a little railroad car, are shoved into a boiler, where from 4 to 6 lbs. pressure of steam is applied. When the colors have been thoroughly fixed by the means we have stated, the skeins are dried and passed through what are termed setting machines, when the yarn is ready for the Bigelow loom. These have on the end of each of the little wires used to raise the pile of the Brussels carpet, a small knife, which, while it weaves, cuts the pile and makes it "velvet." The next machines to which the fabric is subjected, are for shaving the velvet, and girls are employed in trimming the under side of the goods and preparing them for the rolling machine. Here the carpets are rolled, marked with the number of the pattern of each roll, number of yards, etc., and thus prepared for removal to the warehouse. The lengths of the pieces usually are: velvets, from 40 to 50 yards; tapestries, 50 to 60 yards; and ingrains, from 100 to 110 yards.

The quantity of carpets made in New York and Massachusetts, according to the respective state censuses of 1855, was as follows:—

	Wool used. lbs.	Carpets made. yards.
New York	3,707,500	1,820,500
Massachusetts	2,880,974	1,988,460
Total two states..	6,588,474	3,808,960

The manufacture of long shawls, for men's use, was pushed to a great extent a few years since, when the fashion was more prevalent than now. The Bay State Mills became famous for that description of goods, the manufacture of which required 3,000,000 lbs. of wool per annum.

The delicate yarn, known as zephyr worsted, is much used on these machines, greatly promoting the manufacture of those articles which it has been the rage to knit of late. The demand for that yarn causes frauds to enter into the sale. Each pound of zephyr is divided into 16 laps, which are sold without weighing, as containing each one ounce of wool. Full weight would be 16 drachms to the ounce lap, or if stored in over dry atmosphere, 15¾ drachms; but the fraud consists in putting up only 15, 14, 12, or 10 drachms in each ounce lap, the number of laps in a pound being the correct number—16. These frauds are difficult to detect, as the dishonest dealer is provided with false weights, which make his goods appear on trial to be correct. The ounce of the apothecary shops contains more grains than the true standard avoirdupois ounce, so that it cannot be tested there. The proper remedy would be to inquire continually of dealers whether their goods are full weight or short weight, to show that public attention is directed to the matter, and to compare articles bought at different stores, by putting them on the opposite scales of a balance, and noticing where goods are sold by true or best weight.

The production of hosiery and fancy knit work has become very important in the last ten or fifteen years. The supply of those articles came previously from England, but within that time the manufacture of these articles has received a great development, particularly in Philadelphia. The fine American wool is well adapted to the manufacture. The business is largely carried on in families and by hand looms. There are large factories devoted to the production of opera hoods, scarfs, comforters, etc. The wool is prepared in the usual way, by carding and spinning, and is bleached, dyed, and printed according to the designs required. In the weaving, some fifteen or twenty different kinds of looms are employed. One has recently been invented for weaving neck-comforts. It weaves four neck-comforts of a double fabric, and each of a different pattern. The Jacquard principle, used in carpets for years, is applied to it, and almost any design may be produced. The machinery is changed to suit the goods—hoods,

talmas, opera cloaks, neck-comforts, scarfs, hose of every description. A large establishment in Philadelphia uses 250,000 lbs. of wool per annum in these articles.

CHAPTER II.

CLOTHING TRADE—TOTAL MANUFACTURE —SHODDY.

Until within the last twenty-five years, the ready-made clothing trade was confined almost entirely to the furnishing of sailors' sea fit-outs, or slops. The stores for this purpose were mostly in the neighborhood of shipping offices, and kept to some extent by sailor landlords, whose business philanthropy led them to coax "poor Jack" into their "cribs" on his arrival, and feast him high while his earnings lasted; and as soon as these were nearly gone, ship him on board some vessel, obtain his advance pay, which is, in the navy, three months, or $36, and in the merchant marine, one month, varying from $12 to $20, according to the demand for seamen. If this is not all due the landlord, he supplies slops at enormous rates for the balance, gets Jack dead drunk, and puts him on board at the last moment in that condition. In such a business, ready-made clothing was indispensable, but otherwise there was little market for made-up goods. Most families in the country made their own clothes. But as taste and wealth improved, the difficulty of "cutting out" called into being a special trade, and most villages and towns in the country were visited by professional persons, who boarded round in the families where cutting and fitting, as well for males as females, was in requisition. Another trade also grew up in the cities; it was the dealing in second-hand clothing, mostly by Jews. These industrious persons bought up all the old clothing that could be had, cleaned, repaired, and redressed them, and sold them to those who sought to economize. The cleaning and repairing of these clothes occupied great numbers of poor people. The repairing soon grew into fabricating very cheap cloths bought at auction, "half-burnt," "wet goods," etc., to sell them in connection with the old garments. Visitors from the country found that garments could be bought in this way to better advantage than even to have them made at home, and the boarding-round system began to wane. It was soon found in New York that the great crowd of visitors who passed rapidly through the city, and had little time to wait for measures, or to be inconvenienced with tailors' delays and misfits, would become buyers of a better class of ready-made clothing, and the manufacture began to spread by tailors keeping assortments. The visitors who thus bought at retail were disposed to extend orders for resale at home, and in 1834 and 1835 the wholesale manufacture commenced in New York. One of the first of these, a shrewd judge of cloth and a close reckoner, commenced with little capital, slept under his counter, and kept his personal expenses very small, devoting his whole time to the cheap purchase of cloth, and the most economical way of making it up. This trade grew rapidly to an expenditure of $80,000 per annum for labor, mostly to sewing girls, at ridiculously low prices. This work was done to a considerable extent by girls who, living with their parents, wished to increase their allowance for dress. It is obvious that where the purchase of goods, the cutting, and making are attended to by experienced men, on a large scale, the cost of the goods must be very much less than that at which individuals could get them up, and the competition of the clothiers guarantees that the profits shall not be exorbitant. There were many in the trade when the revulsion of 1837 ruined them. The trade was soon again re-established, and it has not since ceased to grow, not only in New York, but to spread into all the cities of the Union. The census of 1850 gave the clothing business as follows:—

Number	4,278
Capital	$12,509,161
Cost of material	$25,730,258
Males employed	35,151
Females employed	61,500
Cost of labor	$15,032,340
Value produced	$48,311,709

This production in amount ranks third of the occupations of the Union. Since then the increase has been very much greater, and the business is now so extensive, that the "purchases of the clothiers" are a regulating feature in the goods market. These purchases take place many months before the goods are sold. The cloths for winter goods are bought in the previous spring, in order to give time for the making up. In a large clothing establishment, the business proceeds with great method. The cloth, as soon as it

comes in, is subjected to a rigid scrutiny, and blemished portions are removed. The piece is then taken to the superintendent, a statement of the number of yards, the cost, and of whom purchased, is then entered in a book kept for the purpose. There is also entered the number and description of the goods to be made, how they are to be trimmed, the name of the cutter, the price of making, etc. The cloth is then transferred to the cutter, with directions as to kind of garment, style of cut, sizes, etc. The garments being cut, are passed to the trimmer, who supplies buttons, thread, lining, etc. The goods then come under the control of the foremen, of whom there are several, and these give them out to be made. The number who do this part of the business is very large, and are mostly females. They take home pantaloons, vests, etc., and when not well known to the foreman, are required to leave a deposit in money for the return of the goods. This is necessary in large cities, since it happens that if there is no deposit, the person may be tempted to pawn or sell the goods; or, if she is honest, she may have a drunken husband, who will seize and pawn the goods. It often happens, however, that poor, deserving women have no money to deposit, and go hungry in face of work that they might do. There are, on the other hand, knavish dealers, who, taking advantage of the position of the depositor, require it, and when the goods are returned, declare the work ill done, and retain the deposit to pay for the alleged spoiling of the cloth. There are also great numbers of men employed in doing the heavy work, and since the introduction of sewing machines, these have been greatly employed. The large immigration into New York has caused a great supply of German and other families, who take in sewing, and these nearly all have a sewing machine. This demand for the machines is supplied by the liberality of the competing patentees. They deliver a machine upon the payment of a small sum, and allow the buyer to pay up a dollar or two a month until the purchase is completed. In this manner the supply of labor in the manufacture of clothing is greatly increased, but the pressure is harder upon those who have no machines. The women may, however, earn from $3 to $5 per week; the former price on coarse work was as low as 25 to 37½ cts. for common silk vests, and as much for pantaloons, of which two pair a day is a large production. For custom-made silk vests, $1 is paid. The finer coats are made by regular tailors, employed in fashionable city shops during the dull season, and these earn $7 to $12 per week. The supply of labor is not, however, confined to the city, but embraces a broad circle of country, to which goods are sent by rail and express to be made up. Many clothing concerns have agencies in the country towns. These keep vehicles to travel round to farmers' and other dwellings where good sewing is done in the winter, with his goods, and bring them back when done. This reverses the old system of boarding round to cut out family goods, since the goods go round to get made up. The energy with which the trade is driven, therefore, produces two competitions, one to get the work done, and the other to get the goods sold.

The cutting is an "art" of itself, and requires a certain talent. It is, in fact, the most important part of the manufacturing, since the style and "set" of the goods depend upon it. The large New York clothing stores employ the best "talent" in this line. The majority of the goods made up in New York and Philadelphia, is for the south and west. The capital required is large, since the goods are to be purchased some four or five months in advance of the season; much cash is paid out in the manufacturing, and finally, sales made at six to eight months. This manufacture includes all styles of boys' clothing as well as men's. The house of Brooks Brothers sell $1,000,000 per annum, and pay out $200,000 for sewing. This is stated at one-hundredth part of the clothing business of New York.

The clothing trade of Boston has also received a great development of late years, and by a combination of circumstances which have had their influence everywhere. In 1840 there were only two houses in the trade in Boston, and the aggregate sales were about $200,000. These have now increased to thirty-five houses, with sales not much short of $15,000,000 per annum. The supply of goods of home manufacture is large in Boston—as well from the manufacturers direct, as through commission houses who advance on them to the manufacturers. The cutting is done in Boston, but the sewing is mostly done in the farmers' families throughout New England, and about 60,000 females in such situations are employed. The numerous railroads that traverse the country, make commodities cheap;

and as sewing machines improve in the quality of the work they do, and in the cheapness with which they can be furnished; hardly a house is without one, and all seek employment for them. In 1857, when the financial pressure caused so many mills to stop, throwing hands out of employment, these sought sewing as a substitute; and their savings enabled them to buy machines. The same event threw large quantities of goods upon the market, through the auction houses, and also through the hands of the commission houses, to whom the manufacturers pledged them for money. Thus, there was a large supply of goods and labor at less than former rates; clothing could be furnished much cheaper, and this circumstance was not advantageous to the old stocks. That circumstance, temporary in itself, gave an impulse to the clothing business, as bringing more within its scope.

The national census returns of 1840 and 1850 gave some details of the manufacture of woollen in each state, at each of those periods. That of 1850 was the most full, and is as follows:—

WOOLLEN MANUFACTURES OF THE UNITED STATES FOR 1850.

	Capital invested.	Pounds of wool used.	Value of all raw material.	Number of hands employed. Male.	Female.	Value of entire products.	Yards of cloth manufactu'd.
Maine	$407,600	1,438,434	$495,940	310	314	$753,300	1,023,020
New Hampshire	2,437,700	3,604,103	1,267,329	926	1,201	2,127,745	9,712,840
Vermont	886,300	2,228,100	830,634	683	710	1,579,161	2,830,460
Massachusetts	9,089,342	22,229,952	8,671,671	6,167	4,963	12,770,565	25,865,658
Rhode Island	1,013,370	4,103,370	1,463,900	987	771	2,331,825	8,612,400
Connecticut	3,773,950	6,414,100	3,325,709	2,907	2,581	6,465,216	9,408,777
New York	4,459,370	12,538,786	3,838,292	4,262	2,412	7,030,604	7,924,352
New Jersey	494,274	1,510,289	548,367	411	487	1,164,446	771,100
Pennsylvania	3,005,064	7,560,379	3,282,718	3,490	2,236	5,321,866	10,095,234
Delaware	148,500	393,000	204,172	122	18	251,010	152,000
Maryland	244,000	430,300	165,565	262	100	295,140	373,100
Virginia	392,640	1,554,110	488,899	478	190	841,013	2,037,025
North Carolina	18,000	30,600	13,950	15	15	23,750	34,000
Georgia	68,000	153,816	30,392	40	38	88,750	340,600
Texas	8,000	30,000	10,000	4	4	15,000	14,000
Tennessee	10,900	6,200	1,675	15	2	6,310	..
Kentucky	249,820	673,900	205,287	266	62	318,819	878,034
Ohio	870,220	1,657,726	578,423	903	298	1,111,027	1,374,087
Michigan	91,600	162,250	43,402	78	51	90,242	141,570
Indiana	171,545	413,350	120,486	189	57	205,802	235,500
Illinois	154,500	396,964	115,367	124	54	206,572	306,995
Missouri	20,000	80,000	16,000	15	10	56,000	12,000
Iowa	10,000	14,500	3,500	7	..	13,000	14,000
Wisconsin	31,225	134,200	32,630	25	..	87,992	36,000
District of Columbia	700	5,000	1,630	2	..	2,400	10,000
Total for 1850	$28,056,220	67,762,829	$25,755,938	22,678	16,574	$43,157,555	82,202,692
" 1840	15,765,124	50,808,524		21,342		20,696,699	

In addition to these yards of cloth made, there were 4,294,326 lbs. of yarn made. Deducting the yarn from the gross amount of wool used, leaves 62,500,000 lbs. weight into 82,000,000 yards of cloth, or about a yard and a third for one pound of wool. The number of yards made in 1840 was not reported; and that of 1850 comprises so many various articles as to give no accurate idea of the matter. There was, apparently, a small increase of the business in some of the western states, and in others a decrease. In Tennessee the manufacture declined; in Alabama, Louisiana, and Mississippi, it has not taken root; in South Carolina it died out, while in Georgia it increased considerably. Massachusetts and New Hampshire showed the largest increase. The manufacture appears to confine itself mostly to the middle states; curiously enough, to those states which are most exposed to the competition of the imported goods.

We have seen it stated above, that the manufacture of woollens in the United States increased from 20,000,000 in 1840, to 43,000,000 in 1850, according to the national census. The statistical accounts of the general progress are very meagre. We may, however, extract from the state censuses of New York and of Massachusetts, for 1855, the figures in relation to the woollen manufactures in those states. The manufactures

in the states of New York and Massachusetts, were given as follows :—

MASSACHUSETTS.

Broadcloth	yards 759,627
Cassimeres	" 6,444,585
Satinets	" 6,736,082
Jeans	" 1,948,609
Flannels and blankets	" 10,279,227
Yarn	lbs. 689,957
Carpets	yds. 1,988,460
Wool used	lbs. 21,667,272

NEW YORK.

Cloth	yds. 4,836,834
Yarn	lbs. 506,178
Shawls	no. 188,000
Blankets	prs. 48,000
Knit goods	doz. 15,384
Shoddy	lbs. 348,000
Carpets	yds. 1,820,500
Wool used	lbs. 15 325,283

These figures show little increase in the quantity of wool used in either state. In fact, this is a decline of nearly 600,000 lbs. in the wool used in Massachusetts, and an increase of only 2,880,000 in the quantity used in New York. This has in some degree been owing to the lessened production of shawls, that at one time took so large an amount of wool. The following figures, from a well informed source, show the number of factories, sets of machines, and quantity of wool required to feed them, in New England and New York, at this moment :—

	Factories.	Sets.	Wool required.
Maine	32	91	lbs. 2,065,000
New Hampshire	56	228	5,670,000
Vermont	56	122	2,375,000
Massachusetts	154	999	31,017,000
Connecticut	93	410	12,155,000
Rhode Island	56	225	5,625,000
New York		468	10,590,000
			lbs. 69,497,000

The production of cloths labors under disadvantage from the sharp competition which the English, Belgians, and French have kept up to obtain the American market. Up to 1840, 19-20ths of the cloths and cassimeres imported into the United States were of English manufacture. At that date they lost ground, but have since recovered. The importations have been as follows :—

IMPORTS OF CLOTHS AND CASSIMERES INTO THE UNITED STATES.

	Germany.	Belgium.	France.	England.	Total.
1840,	16,612	93,135	89,767	4,490,830	$4,690,844
1848,	716,931	396,712	2,466,392	2,777,612	6,357,557
1851,	1,411,282	478,582	1,988,181	3,785,070	7,463,065
1857,	2,574,871	909,331	1,659,470	5,711,933	10,855,605

The tariff of 1841 and 1842 approached, by the biennial reductions, the 20 per cent. horizontal rate contemplated by the compromise tariff, for the last and subsequent years of its operation : that is to say, cloth paid 50 per cent. in 1822, 38 per cent. in 1840 and 1841, and 29 per cent. in 1842 to June 30. By the tariff of 1842 it paid 40 per cent., and by the present tariff 30 per cent. It may be observed, that with the advance of duty from 29 per cent. under the last year of compromise, to 40 per cent. in 1844, the import of cloths in the aggregate increased, but this increase came from the continent, and the maximum importation was in 1845. In the year 1848 the quantities received from France, stimulated by the export bounty of the revolutionary government, increased 50 per cent., and the same influence caused cloths to come from Germany in greater quantities. The Belgians and Germans were here in great numbers, at the Crystal Palace exhibition, seeking to introduce their wares, and with more or less success. The result is, that the aggregate value of foreign cloths consumed in the United States did not increase, although the population increased at least 5,000,000 of people. The superior dye and finish of the German and French cloths have been the main reasons for their supplanting the English in our markets. The English manufacturers have now, by outlay of capital and increased exertions, obtained more or less success in recovering their ground; and against this sharp competition of France, Germany, and England, our manufacturers have hitherto fully maintained their ground, as appears from the fact, that while the increase of population and the wealth of that population has been very large within ten years, and the market for foreign goods has been extended, yet, on the other hand, most of the increased consumption of the country, in the double ratio of greater number and enhanced means, has been supplied from our own production under shield of a 30 per cent. duty. The importation of shawls was very much increased in the same period of time, under similar conditions in reference to the successful competition of Europe against England. But the manufacture of these articles in this country has also immensely increased in the same time. The attention of farmers in the last two years has been powerfully directed to this great staple, and the degree of prosperity which it manifests is well calculated to extend their enterprise not only to the number of sheep, but to the quality—

in respect not merely of breeds, but in keeping clean and packing. The fact has been developed by the most elaborate scientific researches, that the climate and soil of the United States are better adapted to the growth of fine, long stapled wools, suitable for the cloth manufacturer, than any other *manufacturing* country, and the article produced exceeds the Australian wool. Under the appliances of increased capital, and the stimulus which the competition of England with the continent may impart to the quality of the fabric, the United States will probably assume the superiority; but our manufacturers should not neglect the necessary exertion to procure as fine a finish and as durable a dye for their cloths as those of the continent exhibit. The United States wools are rapidly gaining a character which will bring the foreign manufacturers into such competition for its purchase as will permanently sustain its price.

The supply of wool in the United States has never been equal to the demand. In 1840 and 1850 the census gave the quantities raised in the country. If to these we add the quantities imported, we approximate the quantity used as follows:—

	1840.	1850.
United States product..lbs.	35,802,114	52,516,969
Imported.....	15,006,410	18,669,794
Total manufactured..lbs.	50,808,524	71,186,763

These wools, imported into the United States, are mostly of the coarser descriptions used for carpets, etc., and the average value is about 10 to 11 cts. These are qualities which do not compete with the fine wools of American growth; but the growth of manufactures was found to be impeded by the want of greater supply. In consequence, Congress, in 1857, made all wools costing less than 20 cents at the place of growth, free of duty. These had paid 30 per cent., ad valorem, previously. This law had not much effect in increasing the supply, for the reason that the supply is everywhere short. There were quantities of South American wool imported of a fine quality, but so filled with the burr peculiar to that country, as to make them nearly useless. Many machines were invented to remove these burrs, but with partial success. One was of the form of a number of circular saws, 8 to 10 inches in diameter, set close together upon a shaft, which revolved with much velocity. The wool was fed to this cylinder, through two rollers. The saw teeth seized the wool, which, passing between the saws, left the burr on the surface, whence it was removed by the motion of the cylinder against a stationary knife placed longitudinally across it. The general impulse given to manufactures at home and abroad, has caused the demand to outrun the supply of wool. This was the more the case that manufactures spread in those countries that formerly were most depended upon for raw wools. The supply of England has been kept up by the extended exports of Australia and the Cape of Good Hope. Hence, the lower duty did not improve the supply in the United States, and the home supply has to some extent been diminished by the operation of railroads and the growth of large cities. These latter have raised the demand for mutton and lamb, while the easy transportation afforded by rail has induced the farmers to send the animals to market instead of the wool, which was formerly alone practicable. The price of wool accordingly rose, and the manufacturers naturally sought to reduce the cost of the raw material by hunting up a substitute. This is usually found in substituting one of these four chief materials of human clothing—cotton, silk, wool, and flax. The one of these that is relatively dearest is mixed with larger proportions of the others. Hence, the value of the whole becomes in some degree equalized.

Out of these circumstances has grown one of the most curious manufactures that have sprung up of late years. This is the shoddy manufacture. It has recently been imported from England; and there are now in New York state six factories—in Watervliet, Newburg, Troy, and Marlborough. These turn out about 100,000 lbs. of shoddy per annum.

But what is shoddy?

In the somewhat hilly district of Yorkshire, between Huddersfield and Leeds, stand on two prominences the pretty little towns of Dewsbury and Batley Car. The stranger, on alighting from the railway car, is struck with the unusually large warehouses, built of stone, by the railway company. For such small stations, these are mysterious erections. But if he enter the principal warehouse, he will probably find piled up hundreds of bales, containing the cast-off garments of Great Britain and the continent of Europe. Here, in fact, from all parts of the world, are brought the tattered remains of the clothes, some of which have been worn by royalty in

the various courts of Europe, as well as by the peers and peasants. The rich broadcloth of the English nobles here commingles with the livery of their servants and the worsted blouses of the French republicans; while American undershirts, pantaloons, and all other worsted or woollen goods, may there be found, all reduced to one common level, and known by one common appellation of "rags."

The walls of the town are placarded with papers announcing public auctions of "Scotch shoddles," "mungoes," "rags," and such like articles of merchandise, and every few days the goods department of the railway is besieged by sturdy-looking Yorkshiremen, who are examining, with great attention, the various bales, some of which are assorted into "whites," "blue stockings," "black stockings," "carpets," "shawls," "stuffs," "shirtings," "linseys," "black cloth," etc. A jovial-looking man, of doubtful temperance principles, at last steps forward and puts the goods up to auction. The prices which these worn-out articles fetch are surprising to the uninitiated. Old stockings will realize from $35 to $50 a ton; while white flannels will sometimes sell for as much as $100 a ton, and even more. The "hards," or black cloth, when clipped free from all seams and threads, are worth from $100 to $150 a ton. There are common mixed sorts of coarse fabric which can be bought as low as from $15 to $25 a ton; while the "rubbish," consisting of seams, linseys, and indescribables, are purchased by the chemists for the manufacture of potash crystals for from $10 to $15 a ton.

It will be seen that *assorting* these old woollens is equally important with the assorting of the different qualities of new wool; and there is the additional consideration of colors to render assorting still more necessary. It is surprising, however, with what rapidity all this is accomplished. There are some houses where old woollen rags are divided into upward of twenty different sorts, ready for the manufacturer. The principal varieties are flannels, of which there are "English whites," "Welsh whites," "Irish whites," and "drabs." Each of these command a different price in the market: the English and Welsh being much whiter than the Irish, and of finer texture, are worth nearly double the price of the Irish. The stockings are the next in value to the flannels, on account of the strength and elasticity of the wool. The peculiar stitch or bend of the worsted in stocking manufacture, and the hot water and washing to which they are submitted during their stocking existence, have the effect of producing a permanent elasticity which no after process destroys, and no new wool can be found to possess. Hence, old stockings are always in great demand, and realize, for good clean colored sorts, as much as $80 a ton in busy seasons. The white worsted stockings are the most valuable of the "softs," and, when supplied in sufficient quantity, will sell for as much as $140 a ton. Carpets, and other colored sorts, are generally, owing to their rapid accumulation, to be had at very low prices.

"Shoddy," so well understood in Yorkshire, is the general term for the wool produced by the grinding, or, more technically, the "pulling" up of all the soft woollens; and all woollens are soft, except the superfine cloths. The usual method of converting woollens into shoddy, is to first carefully assort them, so as to see that not a particle of cotton remains on them, and then to pass them through a rag machine. This has a cylinder 3 ft. in diameter and 20 inches long, with steel teeth half an inch apart from each other, and standing out from the cylinder, when new, one inch. This cylinder revolves five hundred times in a minute, and the rags are drawn gradually close to its surface by two fluted iron rollers, the upper one of which is packed with thin stuff or skirting, so as to press the rags the closer to the action of the teeth. The cylinder runs upward past these rollers, and any pieces of rag which are not completely torn into wool, are, by their natural gravity, thrown back upon the rags which are slowly creeping into the machine. The rollers are fed by means of a creeper, or slowly moving, endless cloth, on which a man, and in some instances a woman, lays the rags in proper quantities. One of these machines is commonly driven by a seven-inch band, and requires at least five horse power. Half a ton of rags can be pulled in ten hours by one of these machines. The dust produced subjects the workpeople on first commencing the occupation, to what is there called the "rag fever." But after a time the immediate effects are warded off, and although it no doubt shortens life, the remuneration being considerable—in England, 2s. for every 240 lbs. of rags pulled—there is never any difficulty in obtaining workpeople.

The "mungo" is the wool produced by subjecting the hards, or superfine cloths, to a similar operation as that above described. The machine, however, for the mungo trade, is made with a greater number of teeth, several thousand more in the same sized cylinder, and the cylinder runs about 700 revolutions in a minute. The rags, previous to being pulled in this machine, are passed through a machine called a "shaker." This is made of a coarsely-toothed cylinder, about 2½ ft. in diameter, which revolves about 300 times in a minute, in a coarse wire cylinder. This takes away a large portion of the dust, which is driven out at a large chimney by means of a fan. The mungo pulling is, therefore, a cleaner business than the shoddy making, and, as a general rule, is more profitable. The power required for a mungo machine is that of about seven horses.

Both the better kinds of shoddy and the mungo have for some years been saturated with oil; but recently, milk has been applied to this purpose, and found to answer exceedingly well. The consequence was, that milk in that locality, in England, has risen 100 per cent. in price; and even in that district, where cows are kept in large numbers, it was feared there would be a great scarcity of milk for the supply of the towns.

When well saturated with oil or milk, the shoddy or the mungo is sold to the woollen manufacturer. There are scores of men who attend the Huddersfield market every Tuesday to dispose of their mungo. It is as much an article of marketable value there, as cloth is here. It is not unusual for good mungo to realize as much as eight English pence per pound, while the shoddy varies in price from one penny to sixpence per pound, according to quality.

The common kinds of shoddy require, of course, to be subjected to the scouring process, for which large wooden heaters, or "stocks," are employed. The dung of hogs is largely employed in this purifying process, as well as human urine, which is extensively used in the blanket manufacture of Yorkshire.

The white shoddy is capable of being used either for light-colored goods or for the common kinds of blankets, while the dark-colored shoddy is worked into all kinds of coarse cloths, carpets, etc., which are dyed any dark color, so as to hide the various colors of the old fabrics. It is mixed in with new wool in such proportion as its quality will permit, without deteriorating the sale of the material.

The mungo is used in nearly all the Yorkshire superfine cloths, and in some very extensively. It produces a cloth somewhat inferior, of course, to the West of England goods in durability, but, for finish and appearance, when first made up, the inferiority would only be perceived by a good judge of cloth. This substance is largely introduced into all felted fabrics. Blankets, carpets, druggets, table-covers, and Petersham coats, are sometimes entirely made from it, and the trade is rapidly extending.

The effect of shoddy in the cloth of an overcoat, in the wear, is to rub out of the cloth and accumulate between it and the lining. We have seen a gentleman take a handful of this short wool from the corners of his coat.

The grounds on which this shoddy and mungo business can be justified are the cheapening of cloth, and the turning to a useful purpose what would be otherwise almost useless.

The business in Yorkshire is dignified by the title of the "Dewsbury trade;" and to it Dewsbury certainly owes its wealth, and we might almost say its existence. In twenty years it has grown from a village to a town of some 30,000 inhabitants, and some immense fortunes have been made by this extraordinary transformation of old garments into new.

Considerable quantities of white shoddy were sent from England and Scotland to this country, and finally a machinist sent several of his rag machines, and several factories were successively started. The sale of the product is now largely conducted in Cedar street, New York.

The shoddy trade is somewhat fluctuating, being affected very much by the state of the wool market. So great is the competition in the markets, that as soon as a rise takes place in the price of new wool, the small manufacturers, instead of raising their prices, commonly regulate their expenditure by using a larger proportion of the old material, and they are thus enabled to compete, in prices at least, with the larger manufacturers, who can lay in a large stock of new wool when the prices are low.

LEATHER.

CHAPTER I.

TANNING—BOOTS AND SHOES.

On the formation of the federal government, much solicitude was apparent in relation to the growth of the more important branches of manufactures. That the imperial government had so persistently prevented the establishment of any considerable branches, was a great drawback, because it had prevented the development of the necessary experience and skill in manufacture required for large operations. The removal of those prohibitions by the act of independence, attracted attention to the forbidden industries, and they began to flourish. The tanning and manufacture of leather, in all its branches, was one of the first that began to thrive, and naturally, because the slaughter of animals for food furnished a greater or less supply of skins, that required to be wrought up into boots, shoes, harness, etc. Parliamentary committees, early in the eighteenth century, mentioned tanning in the colonies as a branch of individual industry, which supplied most of the local demands for leather and shoe-making, as one of the leading handicrafts.

In 1791, the Secretary of the Treasury, Mr. Hamilton, in his report on manufactures, mentions: "Tanneries are not only carried on as a regular business in numerous parts of the country, but they constitute, in some places, a valuable item of incidental family manufacture." He went on to mention, that encouragement had been asked of the government in two ways, viz.: by prohibiting both the import of the leather and the export of the bark. It was alleged that the leather trade had raised the price of bark from $3 to $4½ per cord. He ascribed the rise, however, rather to the increase of tanneries than to the export, of which, he said, there was no evidence. Glue was then a large item with the tanners, who used up the refuse portions of the skins in that way. From that time to the present, tanners have increased in all the states, in the proportion nearly of the growth of the population. The importation of boots and shoes was always insignificant, comprising high-priced articles from Paris mostly. Thus, the year 1822 was one of the largest import: there were then 14,979 pairs of shoes, mostly kid and morocco, imported, for $9,192; and 207 pairs of boots, for $792, or nearly $4 per pair. In 1858 the importation was only 39,826 pairs of leather boots and shoes, at a value of $87,101; and the export of domestic boots and shoes in this year was 609,988 pairs, or a value of $663,905: showing a large excess of exports over imports.

The manufacture of boots and shoes has, therefore, been in the double ratio of the number of people, and their ability to buy, in proportions as follows:—

LEATHER MANUFACTURE OF THE UNITED STATES IN 1850.

	Establishments.	Capital.	Raw material.	Male.	Female.	Labor.	Product.
Boots and shoes	11,305	$12,924,919	$23,848,374	72,305	32,949	21,622,608	$53,967,408
Gloves	110	181,200	322,837	329	1,609	233,496	708,184
Leather belting	4	26,000	78,035	15	3	7,656	105,500
Morocco dressers	116	1,387,750	2,286,995	1,796	171	623,772	3,861,895
Patent leather	20	592,100	886,495	687	150	262,248	1,368,300
Saddles and harness	3,515	3,969,379	4,427,006	12,598	360	3,154,008	9,935,474
Tanners and curriers	6,528	20,602,945	22,865,253	22,451	124	5,606,110	37,702,333
Total	21,598	$39,684,293	$54,714,995	110,181	35,366	31,509,898	$107,649,094

The total value was thus raised to $107,649,094. The value produced by the tanners and curriers was $37,702,337. Of this leather, so produced, the harness-makers

and shoe-makers used $28,275,380. The tanneries lie at the foundation of the whole. They use the skins and hides of animals slaughtered in the whole country, and require, in addition, an average of some 5,000,000 of foreign hides, imported mostly from Central and South America, and the British East Indies, to make good the demand. The census of 1840 gave the sides of sole leather tanned at 3,463,611, and of upper leather 3,781,868.

The supply of hides in the country originally was derived mostly, if not altogether, from the slaughter of animals for food. Tanneries were started where bark, mostly hemlock, was most easily accessible, and the tannery became the market for hides and skins for many miles around, as well for the farmers as butchers. In the neighborhood of the large cities, foreign hides became the main resource. Thus, in 1858, the value imported was $9,884,358, as follows: Boston and Salem, $3,290,555; New York, $5,629,027; Philadelphia, $377,635; Baltimore, $422,466. The importers of hides sell to the tanners for cash or short time, and then tanning takes place in localities best suited to the combination of the materials. Boston is the largest leather market in the states; but there is not tanned in Massachusetts half the leather they use. They tan the upper leather; but the sole leather is mostly tanned in New York. The hides imported at Boston and Salem are sold to the New York dealers, by them supplied to the tanners, and then resold to the boot-makers of Massachusetts. One reason of this is, no doubt, that the newly opened counties of New York supply more and cheaper bark than can be had elsewhere. When the Erie railroad was opened through the southern tier of counties, tanneries rapidly increased along its line. The returns of the road for the first five years were as follows:—

	Hides sent west.	Leather sent east.
1846,	lbs. 976,950	781,300
1847,	1,200,520	480,040
1848,	1,111,580	1,078,620
1849,	3,253,883	3,696,592
1850,	10,140,022	8,409,765

So rapid was the effect of having access to new hemlock forests. The number of hides that are produced each year in the country, although a very important item, the census has not furnished in any definite manner. That of 1840 gave the number of sides tanned in 1839 at 3,463,611, which would account for 1,731,805 hides. The number of neat cattle in the country was then 14,971,586, and of horses and mules 4,335,669. The deaths among them would give about 400,000 hides, and the neat cattle would give 3,000,000 hides. The census of 1850 gives the number of cattle as follows:—

Horses	4,336,719
Mules	559,331
Milch cows	6,338,094
Other cattle	9,693,069
Sheep	21,723,220
Working oxen	1,700,744

The census gives the quantity slaughtered at 25 per cent. of the whole. This would give 4,430,000 neat cattle, and 433,000 horse hides. The same census gives 6,128,970 hides tanned, and 8,653,865 skins, including 6,000,000 sheep-skins; which numbers, including the hides imported, would nearly correspond. If we compare the census of 1840 with that of 1850, for tanneries, we have results as follows:—

	No.	Capital.	Sides tanned.	Skins.	Value.
1840,	8,229	$15,650,929	3,643,611	3,781,868	$20,919,110
1850,	6,263	18,900,557	12,257,940	8,653,865	32,861,796

The census of 1850 gives 6,128,970 hides tanned, which gives 12,257,940 sides. Under the head of skins, the census of 1840 has upper leather, calf, horse, etc. The census of 1850 includes 6,000,000 sheep-skins. Now, these 12,257,940 sides of sole leather by no means account for all the shoes made in the country. The rapid rate at which shoes and boots are made and worn, far exceeds the increase of cattle and hides; and the census returns do not obtain any thing like the quantities that are made in the large cities, where the numbers of very poor foreign shoe-makers are large. The census of 1855 gave 24,804 boot and shoe-makers in the state of New York, while the United States census of 1850 gave but 10,439 in the state. This difference, to some extent, no doubt, grew out of the large migration, there being among the emigrants very many shoe-makers who work very cheap and well.

The skins of domestic animals, or "green hides," are rated of higher value than the foreign or salted hides; yet these latter will give a great weight of leather, because of the water in the green hides, which, on the other hand, are more easily handled. The largest oxen make the best sole leather. The skins of the bull are thickest about the neck and

parts of the belly; but the back is thinner, and are inferior in fineness of grain to oxen or cows. The best are made into the heavy leather, used for the best trunks, shoe-soles, machine-belts, harness, etc. The lighter qualities serve for uppers of common boots and shoes. Kips, or skins of young cattle, make the uppers of fine boots and shoes. Those hides of the best quality only are split or shaved for the thin enamelled leather used for ladies' shoes, and are made into "lace leather," or thongs for belts. In preparing the hides for tanning, the heavy ones are soaked for months in lime-water. The hair, at last, can be removed, with the epidermis, by the two-handed scraping-knife, rubbed over it as the hide is laid flat down on the bench prepared for this purpose. The fleshy substance on the other side is then scraped off, and, like the head, cheeks, and other waste, used for making glue. In large establishments, machines are used for this scraping. The lime that remains in the pores of the hide must be removed by soaking in some solution, like chlorine, that will form a soluble compound with the lime. Sometimes hides are laid in piles, and allowed to begin to putrefy, great care being taken to stop it as soon as the hair starts. By the United States plan, the object is more effectively obtained, with less labor, and no injury to the leather. The hides are suspended in a cool vault, protected, like an ice-house, against the entrance of warm air, and furnished with a covered channel-way, that answers as a drain and as a conduit for cool damp air. Cool spring water is then conducted into the vault, to fall round its sides like spray. The hides are thus kept in a mist, at a temperature of 44 to 46 deg., and, in six to twelve days, are found freed from all superfluous matter. The cold vapor has been absorbed, and its action by melting has distended and removed the epidermis with the roots of the hair. As soon as this is effected, the hides are ready for tanning. This American plan, it will be observed, is far in advance of that of the old systems, still practised in Europe.

Of the hides brought into New York in a year, the disposition was as follows:—

Domestic hides, slaughtered	250,000
Imported	1,902,000
Stock, Jan. 1	375,000
Supply	2,527,000

Taken for sole leather	1,877,000	
" upper "	250,000	
" patent "	100,000	
" by western tanners	100,000	
" neighboring cities	150,000	2,477,000
Stock, Dec. 31		50,000

These figures show the relative disposition of the hides sold in New York.

Leather, tanned, is generally divided into three kinds, namely: hides, kips, and skins. The stoutest leather employed for trunks and soles of boots and shoes, is made from butts or backs. Buff leather was formerly made for defensive armor from the hide of the buffalo, but it is now furnished by the cow-hide, and is used chiefly for soldiers' belts. Bull-hide is thicker than cow-hide, while kip-skin, from young cattle, is lighter than the latter. The name kip is also given to Calcutta, Brazil, and African hides. Calf-skin supplies the great demand for the upper part of boots and shoes; sheep-skins form a thin, cheap leather; lamb-skins are used for gloves; goat and kid-skins form a light leather of fine quality; deer or antelope are usually bi-dressed in oil; horse-hide is prepared for harness work, etc., and this, with seal-skin, is used for making enamelled leather; dog-skin makes a thin, tough leather, but most of the gloves sold as dog-skin are made of lamb-skin. Hog-skin makes a thin, porous leather, and is used for covering the seats of saddles; ass and mule-skins are for shagreen leather, used mostly for scabbards. There is a large import trade in skins. The great demand for leather for the best gloves is supplied by lamb-skins from Italy, Spain, the south of France, and other parts, where, in consequence of the lamb being killed quite young, the skin is small, fine, and thin, and is used instead of kid; but it is neither so strong nor so glossy. The skins of lambs that die soon after their birth, are sometimes dressed with the wool, and are used for lining gloves and shoes. The best kid-skins are from the south of France; they are also imported from Germany, Switzerland, Italy, and Ireland. It is said that as soon as the kid begins to feed on herbage, the skin suffers in fineness and delicacy, and is no longer suitable for the best gloves. The best morocco leather is made from Swiss goat-skins; another kind is from Mogador and East Indian goat-skins, which are often made into black morocco, known as "black Spanish

leather," from the circumstance of the first supplies having been obtained from Spain. The leather from the Cape sheep-skin is nearly equal to morocco. Hippopotamus hides are exported from South Africa, and when tanned with oak bark, they make an extremely thick and compact leather. In Canada, recently, leather has been made from the white whale which visits the St. Lawrence. In February, 1860, some specimens of this leather were shown at the American Institute. There are various sorts of excellent leather made from their skins.

The vegetable substances used in tanning have of late years become almost as numerous as the varieties of hides and skins on which they are employed. The active vegetable principle, tannin, varies somewhat according to the source from which it is derived; but it is always marked by an astringent taste, a bluish-black or dark green precipitate, in aqueous solution by admixture with a solution of one of the salts of peroxide of iron; while, with a solution of gelatine, it gives a dirty white or brown precipitate. During a long period the principal tanning material has been oak bark and hemlock bark. That which is stripped in the spring is the most esteemed, for it then contains a larger quantity of tannin than that stripped in autumn, and this more than the bark stripped in winter. The best bark is obtained in a warm spring, from coppice trees about twelve years of age. Oak bark contains from 4 to 22 per cent. of tannin, which is contained in the inner white layers next the alburnum, as in the case of other astringent barks. The tannin of bark is probably not identical with that of galls, as it does not yield pyrogallic acid when subjected to destructive distillation; from four to six pounds of oak bark are required for every pound of leather. After the stripping, the bark is stacked to dry; should the season be rainy, a portion of the tannin may be washed out, and the bark be thus deteriorated. When the tanned leather is taken in hand by the currier, it is softened by being soaked in water. It is next beaten by a mallet upon a hurdle, and then placed over a plank called a beam, which projects slantingly from the floor. The workman leans over this and against the leather, so as to keep it in its place, and with a broad knife shaves off all the irregularities from the flesh side. The knife is held firmly in both hands, and the operator continually examines the skin, and moves it to bring all parts under the knife. After it is shaved, it is thrown into cold water, the flesh side laid next to a stone slab, and the other well rubbed with a tool called a stretching iron. This process forces out a whitish matter (bloom) gathered in the tan pit, and reduces inequalities. Many tools are employed, having the same object. The skin then undergoes "dubbing;" an ointment of cod oil boiled with the skins of sheep, is well rubbed in on both sides, and the leather hung up to dry. It is afterward rubbed with the graining board—an instrument shaped somewhat like a brush, but grooved, and made of hard wood. The leather is then ready for sale; or, after shaving the flesh side with a very sharp knife, it is waxed. A color, composed of oil and lamp-black, is well rubbed in on the flesh side, with a hard brush, until the surface is thoroughly black; upon this is applied a size and tallow with a stiff brush, and when dry, it is rubbed with a broad, smooth lump of glass; this is repeated. This leather is called "waxed," or "black on the flesh," and is used for the uppers of men's boots and shoes. If curried on the other side it is called black on the grain, and is used for ladies' uppers. In preparing such leather, the waxing is performed as follows: a solution of sulphate of iron, called copperas water or iron liquor, is applied to the grain side of the wet skin, when the salt, uniting with the gallic acid of the tan, produces an ink dye; stale urine is then applied to the skin, and when dry, the stuffing is applied. The grain is raised, and when dry, the skin is whitened, bruised, and again grained; after which, a mixture of oil and tallow is applied to the grain side, and it undergoes carefully the treatment with the pommel or graining-board again, and several other processes of rubbing, polishing, and dubbing, or oiling. These duly performed, with due regard to time and circumstances, complete the process.

For many years it was found difficult to cause a bright varnish to adhere to leather without cracking, an effect which is now produced by means of boiled linseed oil mixed with vegetable black and Prussian blue. This composition, of the consistence of a thick paste, is rubbed upon the surface of the leather, and then dried at a temperature of from 150° to 170° Fahr. The process is repeated from three to seven times, and when quite dry, the varnish adheres very

firmly, and will bear considerable flexure and tension without cracking. By mixing colored pigments with the varnish, enamelled leather of various colors may be produced.

The process of tanning differs considerably in the mode of treatment with the kind of skin and the result desired. A large number of thin leathers which are intended to be dyed, are tanned in various ways. White leathers are not tanned, but tawed, or treated with alum, salt, and some other matters. Wash leather is dressed with oil, or shamoyed; but whatever may be the subsequent treatment, the preparatory steps somewhat resemble each other—whereby hair, wool, grease, and other matters, are removed, and the skin is reduced to the state of a gelatinous membrane called pelt; the hair is removed from kid and goat-skin, by means of cream of lime; the wool is generally removed by the feltmongers before the skin is passed to the tawers.

Foreign lamb-skins, which are received with the wool on, are washed, scraped on the flesh side, and sweated in a close room, until, in consequence of the putrefactive fermentation, the wool can be easily removed. After this, fatty matters are got rid of by subjecting the skins to hydrostatic pressure; they are next worked at the beam and pared into shape, treated with lime, and next with dogs' or pigeons' dung, if the skins are to be tanned, and with bran and water if they are to be tawed, the object being, in either case, to get rid of the lime. During these operations, the skins are worked a few times at the beam, and are finished by washing in clean water. Morocco leather is prepared by tanning goat-skins with sumach, and dyeing on the grain side. Inferior moroccos are prepared from sheep-skins similarly treated, for which purpose each skin of pelt is sewed up into a bag, the grain side outermost, distended with air, and placed in a mordant of tin or alum. They are next placed in a warm cochineal bath for red, indigo for blue, orchil for purple, and are worked by hand until the dye has properly struck. For certain colors the tanning precedes the dyeing. The tanning or sumaching is carried on in a large tub, containing a weak solution of sumach in warm water; another and stronger solution is contained in an adjoining vessel, a portion of which, together with some sumach leaves, is poured into the bag; some of the weak solution is then added, the bag is distended with air, and the skin thrown into the vat. In this way about 50 skins are treated, and are kept in motion a few hours in the sumach tub, by means of paddles worked by hand, or by machinery. The skins are then taken out and heaped upon a shelf at the side of the tub, the pressure thus produced causing the liquor to escape slowly through the pores of the skin, the bags being shifted about from time to time. The bags are next passed into a second vat, containing a stronger solution, where they remain for nine hours. The bags are now opened and washed; fine red skins being finished in a bath of saffron. All the skins are next struck on a sloping board until they are smooth and flat, and in order to improve their appearance in the currying, a little linseed oil may be rubbed on the grain side; they are then hung up in a loft to dry, when they become horny and are in the crust, as it is called; they next pass through much laborious friction with the pommel, and with a glass ball; while the peculiar ribbed appearance of morocco is given by means of a ball of box-wood, on which is a number of narrow ridges. Sheep-skin morocco is prepared from split skins; the skin-splitting machine resembles in principle that hereafter described, only as the membrane is thinner, certain variations are required. Instead of stretching the skin on a drum, it is passed between two rollers, the lower one of gun-metal, and solid, and the upper made of gum rings; while between the two rollers, and nearly in contact, is the edge of the sharp knife, which is moved by a crank, as hereafter mentioned. When a skin is introduced between the two rollers, it is dragged through against the knife edge and divided, the solid lower roller supporting the membrane, while the upper one, being capable of moving through a small space by means of its rings, adjusts itself to inequalities in the membrane; where this is thin the rings become depressed, and when it is thick they rise up, so that no part escapes the action of the knife. The divided skins are not sewed up into bags, as, from their thinness, they can be sumached quickly.

In preparing white leather by "tawing," the pelt is made as pure as possible; the best kind of leather being prepared from kid-skins, while sheep or lamb-skins make the inferior kinds. They are first fed with alum or salt in a drum or tumbler made like a huge churn; about three pounds of alum

and four pounds of salt being used to 120 skins of average size. The alumina of the alum forms some definite compound with the gelatine of the skins, while the salt serves to whiten them. When taken out, the skins are washed in water, then allowed to ferment in bran and water to remove the surplus alum and salt, and to reduce the thickness. They are next dried in a loft, and become tough and brittle, but they are made soft and glossy by means of a dressing of twenty pounds of wheat flour and the yolks of eight dozen eggs. By rotating the skins in drums for some time the dressing is absorbed, and scarcely any thing but water remains. This dressing is usually repeated, and the skins hung up to dry. The beautiful softness and elasticity of leather is now given by manipulation. The skins are first dipped in clean water, worked upon a board, and staked upon a stretcher or softening iron, consisting of a rounded iron plate fixed to the top of an upright beam, by which the skins are extended and smoothed; they are then finished by being passed over a hot iron.

The tanning of leather, more than almost any other manufacture, is a chemical process, the success of which depends almost wholly upon the skill and judgment with which its complicated manipulations are conducted. To attain the requisite skill in the laboratory of the chemist is evidently impossible; it can only be acquired in the tanning itself, by long and careful attention and observation; and perhaps there is no description of manufacture where so much depends upon practical knowledge, and so little upon mere theory, as in the tanning of leather. The tanning of leather consists in effecting a combination between the gelatine, which is the main constituent of raw hides, and tannin, a peculiar substance, found in the bark of several species of trees—the oak and hemlock chiefly. The processes employed are so various, and the modifications occasioned by temperature, strength of the liquor, and quality and condition of the hides, are so numerous and so different, that hardly any branch of business requires for its successful conduct a greater degree of judgment and experience, and in few arts have there been effected greater improvements. Within twenty years the gain of weight in converting hides into leather has increased nearly fifty per cent.; that is, from a quarter to a third more leather can now be obtained from a given quantity of hides than in the old-fashioned way.

The great improvement in weight seems to have been gained by the judicious use of strong liquors, or "ooze," obtained from finely-ground bark, and by skilful tanning. In order to produce heavy weights, the hides should not be reduced too low in the beam-house, and should be tanned quickly with good strong liquors, particularly in the latter stage of the operation. To green hides, particularly, nothing can be more injurious than to suffer them to remain too long in weak "ooze." They become too much reduced, grow soft, flat, and flabby, lose a portion of their gelatine, and refuse to "plump up." On the other hand, however, the effects of an early application of "ooze," that is too strong and too warm, to green hides, is very injurious. It contracts the surface fibres of the skin, tanning at once the external layers, so "dead," as it is termed, as to shut up the pores, and prevent the tanning from penetrating the interior. This renders the leather harsh and brittle.

In softening hides, and preparing them for the process of tanning, a great deal also depends upon the judgment of the person superintending the operation, inasmuch as the diversities in the qualities and characteristics of hides render it impossible to subject them to any thing more than a general mode of treatment. In "sweating," the character of the hides and the temperature are essential, but ever-varying considerations. As a general rule, however, the milder the process of preparing the hides for the bark, the better. Unnecessarily severe or prolonged treatment is inevitably attended with a loss of gelatine, and a consequent loss of weight and strength in the leather. Too high a temperature is particularly to be avoided.

In almost every lot of hides, particularly the Orinocos, however, there are generally some that prove very intractable, resisting all the ordinary modes of softening. For such, a solution of ashes, potash, or even common salt, will be found to be beneficial.

As we have said, no precise rule can be given as to the length of time required for the preliminary process of soaking and "sweating"—so much depending upon the qualities of the hides, and the temperature at which these operations are conducted.

The following table, however, may be found useful in conveying an approximation to a definite idea of the practice in a large tannery:—

Temperatures.	SOAKING. 40° Days.	50° Days.	60° Days.	70° Days.	SWEATING. 40° Days.	50° Days.	60° Days.	70° Days.
Buenos Ayres hides.....	10 to 12	8 to 12	6 to 8	3 to 6	15 to 20	12 to 16	8 to 12	2 to 3
Carthagena and Laguayra...	8 12	7 9	5 7	2 5	15 20	10 15	6 8	2 3

Salted hides do not require more than about two-thirds the time to soak, but about the same time to sweat. In sweating, the temperature rises as the hides sweat, so that the operation is seldom performed under 50°. It is particularly recommended that, for the tougher hides, the heat should never be greater than 60° or 65°.

After the hides are prepared for tanning, the next process is what is commonly called "handling," which should be performed two or three times a day in a weak ooze, until the grain is colored, new liquor being preferable to old. They are then, after a fortnight, laid away in bark, and changed once in two to four weeks until tanned. Much care and judgment is requisite in proportioning the continually increasing strength of the liquors to the requirements of the leather in the different stages of this process. The liquors should also be kept as cool as possible, within certain limits; but ought never to exceed a temperature of eighty degrees. In fact, a much lower temperature is the maximum point, if the liquor is very strong—too high a heat, with the liquor too strongly charged with the tanning principle, being invariably injurious to the life and color of the leather. From this, it would seem that time is an essential element in the process of tanning, and that we cannot make up for the want of it by increasing the strength of the liquor, or raising the temperature at which the process is conducted, any more than we can fatten an ox or a horse by giving him more than he can eat. It may be questioned whether any patented schemes for the more rapid conversion of hides into leather, will be found, on the whole, to have any practical utility.

We have mentioned the injurious effects resulting from too strong a solution of the active principle of the bark; on the other hand, the use of too weak solutions is to be avoided. Hides that are treated with liquor below the proper strength, become much relaxed in their texture, and lose a portion of their gelatine. The leather necessarily loses in weight and compactness, and is much more porous and pervious to water. The warmer these weak solutions are applied, the greater is this loss of gelatine. To ascertain whether a portion of weak liquor contains any gelatine in solution, it is only necessary to strain a little of it into a glass, and then add a small quantity of a stronger liquor. The excess of tannin in the strong solution, seizing upon the dissolved gelatine in the weak liquor, will combine with it, and be precipitated in flakes of a dark, curdled appearance, to the bottom. In the best tanneries, the greatest strength of liquor used for handling, as indicated by Pike's barometer, is 16°. Of that employed in laying away, the greatest strength varies from 30° to 45°.

After the leather has been thoroughly tanned and rinsed, it will tend very much to improve its color and pliability to stack it up in piles, and allow it to sweat until it becomes a little slippery from a kind of mucus that collects upon the surface. A little oil added at this stage of the process, or just before rolling, is found to be very useful.

Great caution is necessary in the admission of air in drying, when first hung up to dry. No more air than is sufficient to keep the sides from moulding should be allowed. Too much air, or, in other words, if dried too rapidly in a current of air, will injure the color, giving a darker hue, and rendering the leather harsh and brittle. To insure that the thick parts, or butts, shall roll smooth and even with the rest of the piece, it is necessary that the leather should be partially dried before wetting down for rolling, and that, when wet down, it should lie long enough for every side to become equally damp throughout.

In the tanning records of 200,000 sides, an average of the whole time was five months and twenty-seven days. The average weight of the leather was seventeen pounds per side. This, according to the best authorities we have at hand, is considerably below the time employed in England. There, it is no uncommon thing for eight and ten months to be employed in tanning a stock of leather,

and some of the heaviest leather, it is said, takes even fourteen and fifteen months.

A new process of tanning leather has been recently introduced, as follows:—

Sole leather hides for *sweat stock* are prepared for the tan liquors in the usual manner. Limed stock for upper and sole leather, for either hemlock or oak tanning, is limed and washed, and bated by the paddle-wheel handlers; after being properly prepared for the tan liquors, it is then handled in a section of vats, with the liquors communicating in the manner long known as press-leaches, except the order of running the liquors is from near the top of one vat to the bottom of the next, and so on through the whole section, thus "pressing" the weak liquor ahead on to the greener stock, giving a *perfect* gradation of strength of liquor on each pack, stronger or weaker according to the length of time it has been in; each vat is fitted with a paddle-wheel handler, patented June 19th, 1847, and Dec. 24th, 1850, which is used for stirring the stock in the liquors, dispensing with the necessity of handling by hand entirely; in this section stock should be kept about two weeks, then taken out and hung over sticks with head and butt down in layaways, patented August 10th, 1858, and not again moved or seen till well tanned; the layaways are all in one section with the communicating trunks, in the same manner as the handlers; when a pack is taken out *tanned*, a pack from the *handlers* is put into its place, and the weakest liquor in the section is allowed to fill the vat; here every part of every side is in contact with the liquor at all times, and the liquors on *every pack* are becoming stronger every day till tanned; the liquors are kept in motion by small paddle-wheels, which operate on the surface of the liquor over the suspended sides, causing the liquors to pass with a gentle current among the sides, bearing them up, so that they do not rest heavy on the sticks.

Two men's labor is sufficient for all the *yard work* for a tannery working *in* and *out* 150 sides per day, including washing the tanned stock and taking it to the loft.

The results of tanning 144,000 hides were as follows:—

	Weight. lbs.	Average. lbs.	Value.
Hides..... 144,000	3,229,155	22.22	$421,810
Leather, sides, 287,275	5,316,789	18.51	704,044

This gives a considerable increase in the weight of the hides, and the increase in the value of the article is much greater. That covers, of course, commission, labor, interest, profits, etc. The great development given to general business in the last ten years has caused an almost continuous rise in the value of leather and hides. The latter, on being purchased and put in the vats, would thus acquire value from the general rise in the market, in addition to the regular value added by the art of the tanners. There was gradually felt a growing scarcity of hides, and the quantities imported by no means kept pace with the rising value. The quantities and values of hides imported for the few last years were as follows:—

	1850.	1855.	1856.	1857.	1858.
No. hides,	2,572,884	2,434,554	2,360,150	2,651,846	2,493,656
Value,	$5,964,838	4,823,119	5,919,319	7,620,272	8,048,825

This shows that for 79,000 fewer hides, there was paid, in the year 1858, $2,000,000 more money than in 1850, a rate which gives an advance of 37½ per cent. in the value of hides, without inducing a greater supply. Such a fact indicates the growing cost of the raw material for boots and shoes, and also indicates the growing value of the hides of animals throughout the country.

Leather being so costly a substance, great efforts are made to introduce economies in its manufacture and use in every direction. One plan for getting the most possible surface out of a given weight, is to split the thick hides into two thinner sheets. This process, formerly difficult, has of late undergone many improvements. When the hide is sufficiently tanned, it is split sometimes into five thicknesses, from a single one. This is done by various machines, in one of which the knife is 72 inches long, or as long as a hide is wide. A late improvement in Boston makes the knife 80 inches long, and economises 25 per cent. in the stock that before was shaved away. The flesh side of the sheet, with the shanks, are used by the trunk-makers to cover wooden trunks, and blackened on the trunks. Other sheets are subjected to a process called "buffing," which consists in shaving off about half the grain, in order to obtain a softer surface to receive an artificial grain. They are then returned to the tan-yard, and, after being scoured, are retanned in warm liquors. They are then sent to the currier to be prepared for japanning. A new patent has been issued for splitting leather with a circular knife, which is of thin metal, made like a disc, convex side up. This revolves hori-

zontally, with its sharp edge just above a table, over which the leather is stretched, and held down firmly to it by springs. Under the table is a roller, which, by revolving, draws the leather forward against the edge of the revolving knife. The upper side of the leather splits off in curls above the knife, which may be nicely adjusted to make the leather of any thickness.

The general manufacture of boots and shoes had undergone few changes other than those produced by changing fashions and the regular improvements of business, until the introduction of sewing and pegging machines, which have given a great impulse to the production by affecting prices and disturbing localities. The Massachusetts shoe-makers, by their industry, early obtained an ascendancy in the manufacture, and it is one that is easily adopted in an industrious community. The towns in the neighborhood of Boston attracted masons, carpenters, and other workmen, in the winter season, when their own professions were dull, to pursue shoe-making, which was always a resource. The town of Lynn was the most famous; and the facility with which shoes were turned out, led to the legend, that the materials, being stuck to the wall by an awl, were combined in the proper manner by a blow of the lapstone being skilfully aimed at them. There were others who asserted that both boots and shoes grew there spontaneously. Whatever may be the fact, an affluence of these useful articles was always observable there, and thirty years since the sales were mostly in the hands of the New York merchants, to whom most of the New England manufacturers consigned or sold their wares. Gradually this changed. The number of skilled workmen that arrived from abroad became so great, as to fill most of the departments into which the boot trade became divided, as crimping, bottoming, heeling, and finishing; and the pay of the workpeople, by the piece, or the pair, enables each to control his own time, working when they please. These sometimes club their work, and appoint an agent to sell; others, by economy, save their pay, and employ a few men, whose work they direct. These, in the cities, are called "*garret bosses.*" When they succeed in establishing a trade, they conduct the manufactory by a foreman, and open an office in the city, where they sell their wares, and purchase the stock for manufacture. The materials are in this manner better purchased; and as the seller is himself the manufacturer, coming in contact with buyers from all sections, he becomes conversant with the styles adapted to all localities, and the manufactory is by far the better conducted for it. The advantages of this system have made Boston, of late years, the grand centre of such operators, and have drawn thither the jobbers from New York, Philadelphia, Baltimore, Cincinnati, St. Louis, etc., until Boston has become the largest shoe market in the world. The sales of boots and shoes there are $62,000,000 per annum. The number of pairs made in Massachusetts in the year 1860 was as follows:—

Boots	11,578,885
Shoes	32,678,167
Boots and shoes	51,250
Total pairs	44,308,302
Total value	$37,468,355

This was a number sufficient for one and a half pairs for each person, great and small, in the United States; and the number employed in making them was 43,907 males, and 32,652 females: together, 76,559. In 1845, the value, manufactured in Massachusetts, was $14,799,140—an increase of $22,669,215 in the fifteen years; showing the force of concentration of the trade.

The number of cases exported from Boston, in 1859, was as follows:—

	Total year.
Baltimore	62,461
Charleston	17,177
Louisville	21,119
Lexington	2,158
Memphis	3,338
Mobile	2,940
Nashville	18,781
Paducah	1,146
Richmond	1,452
Savannah, Ga.	2,526
St. Louis	55,774
New Orleans	37,686
Philadelphia	56,119
New York	182,207
All others	253,107
Total cases	717,991

This gives a value of over $30,000,000. The class of shoes sent from Boston is not of so fine a character as those which are turned out in Philadelphia. The largest quantity of morocco is made there; and the supply of skins and leather is ample, and of the best quality. The workmen have a reputation for skill, and are paid by the piece.

The work is divided into separate branches. For men's dress boots, the "fitter" is paid 75 cts.; for crimping, 10 cts.; for bottoming, $2 50; heeling, 12 cts. A fast workman earns about $12 per week. The production of boots and shoes in Philadelphia has been placed at $4,141,000, including a quantity made in the state prisons. The introduction of sewing machines has had an important effect upon the manufacture of both boots and shoes, and more recently, the invention of a machine to peg soles promises to make a still greater change in the principal branch of the Lynn manufacture. The machine in question, for which a patent has recently been issued, punches the leather, and inserts the pegs, in an incredibly short time, with the utmost accuracy and efficiency. The sole, when pegged, is perfectly pliable, the pegs forming, apparently, a portion of its substance. The use of these machines is as well adapted to the limited wants of small western towns, as to the grand operations of metropolitan manufacturers, and local wants may, by their action, be so gradually supplied, as to dry up those streams which unite in so extended a demand in Boston.

Let us go into an eastern machine shoe factory. In a small room, partitioned off for the purpose, is a neat and compact steam engine, which carries all the machinery, even to the stitching machines. The remainder of the basement is occupied by machines for cutting, stripping, rolling, and shaping the soles. The stock is then passed to the store above, where the shoes are lasted, and the outer soles are tacked on by hand; by which process they are prepared for pegging. The pegging machines are simple in their construction and mode of operation, but perform the work with great despatch and accuracy, driving the pegs at the rate of fourteen a second. One of the most curious operations of the machine is the manner in which it manufactures the peg for its own use. A strip of wood of the required width, and neatly laid in a coil 100 ft. in length, is put into the machine, and at every revolution it is moved forward, and a peg cut off and driven into the shoe. The rapidity and unerring accuracy with which these machines perform the work, is truly astonishing. After being pegged, the shoes are passed up to the third story, where the bottoms are smoothed, scoured, and brushed, and then sent into the front of the building to be packed, ready for sale and transportation.

Another part of the building is occupied by the women who tend the stitching machines, which are also run by steam: thus saving them from what otherwise must prove a laborious and fatiguing operation.

A dozen hands employed in the manufacture of these pegged shoes will complete about 20 cases per week; and the work being almost entirely accomplished by machinery, gives it a uniformity as to style, shape, and general appearance, which it is impossible to obtain by hand. The pegging machine has been invented but a few years. The work, even now, is said to be fully equal to that performed by hand, and must, therefore, we think, certainly supersede it when the machinery is brought to a higher state of perfection, which, in the nature of things (it being impossible to stay the progress of inventive Yankee genius), must be continually taking place.

The style of making boots and shoes changes in some degree, and is leading manufacturers to introduce improvements, like that of a steel shank, so called, which is a steel spring fixed firmly in the heel, and extending under the hollow of the foot between the soles, to give elasticity to the step. The grades of city work vary with the quality of the material and the labor bestowed. The patent leather custom-made boots command $10 per pair; and the high Russia leather Wellington boots $12; and so down to $10, $8, and $5 for calf-skin; with lower rates for split leather, and ordinary material. The scarcity of material, and the high prices of stock, have driven the poorer class of shoe-makers to the use of old tops, or upper leathers, for both boots and shoes. These are not only refooted for the use of the wearer, but are cut down to make new shoes and boots of a smaller size. Many take much pains to buy up old articles of that description, and reproduce them at rates far below what they could be afforded by regular shoe-makers from new stocks. Much art is used also in economising the soles of cheap goods. A thin under-sole is used; between which and the in-sole, pasteboard, old slips of leather, and other cheap substances, are inserted, to give an appearance of substance. These cheap varieties of shoes supply the wants of those whose means are small, with a semblance of shoeing.

The phrase, "paper soles," is not unfrequently used to designate the extremely thin substance attached to the casings of the dainty little feet of our fair sex, but still that substance is leather. Recently, however, a pair of veritable paper soles were put upon a customer, and worn, though for a very limited time. The victim in the case was a strapping negro fellow, who, allured by the seductive invitation to "walk in and see the cheap clodings," entered a Jew's museum, and purchased a pair of laced boots for $1 50.

They fitted well, and wore well for a few hours, but great was his astonishment when his trotters parted company with his boots, and he was once again barefooted. On examining more closely his purchase, he found that the soles were composed of thick paper board, colored to resemble leather, and pegged to the uppers. The sympathising justice heard his complaint, but could grant no relief.

The New York state census of 1855 gave the following summary of the production of leather, and the manufactures therefrom:—

	Establishments.	Hands.	Capital.	Raw material.	Value produced.	Quantity.
Tanners.....	863	5,525	$3,367,013	9,670,386	$15,642,383	4,244,615 hides.
Boots & shoes	1,463	10,372	1,061,940	2,628,524	6,063,951	1,478,017 pairs.
Harness, &c.	594	1,613	481,571	816,804	1,580,492	13,663 sets. 37,807 trunks.
Pocket-books	12	581	91,430	128,040	369,000	21,600 gross.
Hose, &c.	2	19	1,000	60,000	77,000	
Patent leather	5	67	59,000	113,000	226,500	73,250 skins.
Morocco.....	30	509	223,300	1,304,612	2,899,829	838,795 skins.

The production of leather by tanners exceeds by much the value used by those who work up leather. A great deal of the leather made in this state goes, however, as we have seen, to New England to be used.

The manufacture of gloves has not extended itself in this country so much as some other industries, with the exception of buckskin gloves, which are peculiarly American, combining utility with dress. The use of gloves is becoming far more general in cities than formerly. In early times, the practice of presenting a pair of gloves at funerals to the attending clergy, and others, was carried to such an extent in Massachusetts, that the legislature forbade the practice, under a penalty of £20. In cold regions, gloves are of the warmest wool, or skins, with the fur side out. Buckskin lined with soft wool is often used: the texture changes with the climate to the softest kid and silk. India-rubber gloves are used for many purposes, such as saving the hands of females in many kinds of domestic labor. Some years since, the French government undertook to clear the sewers of Paris from the multitude of rats that infested them, and which had become a formidable nuisance. These rats were of large and divers breeds. It was stated that a contract was entered into with a Parisian glover to purchase the skins for the glove manufacture at a certain price, on the condition that they should not exceed 1,000,000. It resulted that many millions were procured; and the Parisian house having declined, a London glover took the "lot." It is not certain, however, that the skins are of practical value.

The French excel in the manufacture of kid gloves, and Parisian gloves are still without a rival. The difference is seen in the cutting of the skin to the best advantage. This is performed with scissors, after stretching and rubbing the skin upon a marble slab with a blunt knife.

A skin is first cut longitudinally through the middle, by which it is divided into two equal and similar parts; and the single strip, for the palm and back, is next cut off from one end of the half skin. The pieces for the thumb, the gussets for the fingers, and other small pieces to be inserted, must all be worked out either from the same skin, or from others precisely similar. In this work, it is said, "a Frenchman will generally manage to get one or two pairs of gloves more than an Englishman can from the same skins, and these not inferior or scanty, but as well and handsomely shaped as the rest. This clever and adroit manipulation of the leather is an object of great importance in France, where not less than 375,000 dozens of skins of all kinds are cut up into gloves every year." The nearly square piece cut off is folded over upon itself, giving a little more width for the side designed for the back of the hand; and upon this oblong, double strip, the workman, measuring with his eye and finger, marks out the length for the clefts between the

fingers, which he proceeds to cut and shape. Making the hole for the thumb is a matter requiring the greatest skill, for a very slight deviation from the exact shape would cause a bad fit when the parts are sewed together, resulting in unequal strain and speedy fracture when the glove is worn. By late improvements, introduced by M. Jouvin, the thumb-piece, like the fingers, is of the same piece with the rest of the glove, requiring no seam for its attachment. The cutting also is performed in great part by punches of appropriate patterns, and some of these are provided with a toothed apparatus somewhat resembling a comb, which pricks the points for the stitches. The seams are sewed with perfect regularity by placing the edges to be united in the jaws of a vice, which terminates in fine brass teeth, like those of a comb, but only one-twelfth of an inch long. Between these the needle is passed in successive stitches. When the sewing is completed the gloves are stretched, then placed in linen cloth, slightly damp, and beaten, by which they are rendered softer and more flexible. The last operation is pressing. The chief branch of the manufacture carried on in the United States is that of buckskin gloves; and the most important seat of this business is at Gloversville, Fulton county, N. Y.

It follows, from what has been said, that the United States are large consumers of leather; and when we consider that we are largely a grazing and cattle-growing nation, manufacturing from our native hides a greater quantity of leather than any other nation of equal population, in addition to large imports, it would seem to indicate an extravagant, if not a wasteful use of leather.

We are informed by Adam Smith, who has delineated every point and line of every branch of political economy, and who has, apparently, collected and compressed into three volumes more of the critical history of the individual, as well as the general economy of human society, than any one author, and with less of error and mistake than most authors, that it is characteristic with savage nations to export their raw hides, and neither to manufacture nor use much leather; while civilized nations import largely of raw hides, and manufacture and consume large quantities of leather. It is a fair corollary, then, that our excessive consumption of leather indicates our superior degree of civilization; and such is undoubtedly the truth. The high grade of civilization of the people of the United States is abundantly evident, and universally acknowledged.

FIRE-ARMS.

CHAPTER I.

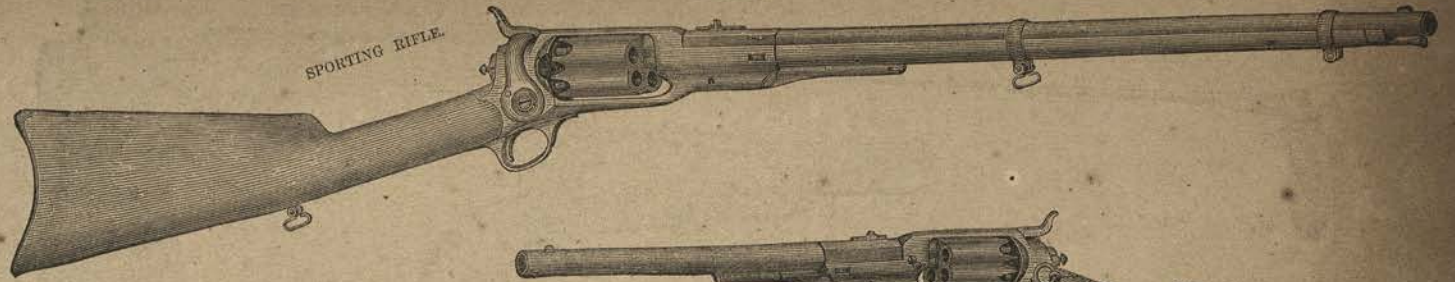
COLT'S REVOLVERS — SHARP'S RIFLES — DAHLGREN'S GUNS.

THE improvements in fire-arms are making such rapid progress among civilized nations, that we may indulge the hope that they will soon cease to be wanted at all; since, as extremes meet, they may become so effectual in their operation, and war reduced to such a science, that an attempt to fight will only be entire mutual destruction, like that most effectual combat between the two Kilkenny cats. The last war in Europe, by which France, in three months, liberated Italy from Austrian grasp, is an example of the power that may now be exerted in a short space of time, and the newly invented rifled cannon had a powerful agency in bringing matters to a close. After the invention of gunpowder in the fourteenth century, the art of gunnery made great progress, and the musket came to be the most important weapon. The Roman legions used the short stabbing sword as their favorite weapon. In the age of chivalry, the lance of the horseman was the queen of weapons, and continued so up to the battle of Pavia, in 1525, when chivalry made its last charge, and went down with the white *panache* of the gallant Francis I. From that time the arquebuse, then a matchlock, improved into a firelock, displaced the English bow, acquired the bayonet, and became, in its turn, the "queen of weapons." When the musket, or "Brown Bess," was furnished with percussion caps instead of flints, and the sword bayonet was added, there seemed to be little to hope for in the way of improvement. Since the "wars of the Roses" in England, nine-tenths of all the battles of the world have been decided by projectiles, artillery, and musketry, without crossing a bayonet or drawing a sword. The cavalry, as an arm, has continually lost ground, except in the rout of a defeat, when it follows up a flying enemy. It never could break a square, even when armed only with pikes, and recent events have shown that it cannot reach infantry in line.

A remarkable change has come over "Brown Bess" of late, and it seems now to have seen its best days. The rifle, or a screwed barrel, was among the first forms of the manufacture of small arms in the sixteenth century; but the musket was preferred, on account of its more speedy loading. The rifle was, however, the favorite with the American colonists, and its execution in their hands during the Revolution brought it into general notice. The adding of the percussion cap was a great improvement to it. Recently it has become so improved as to supplant not only the old musket, but artillery also, since the events of the last few years have shown that it is easy to silence cannon by shooting down the gunners at their pieces, beyond the reach of grape. In the text-book of the St. Cyr Military School of France, it is directed that the fire of artillery should cease when the enemy is distant twelve hundred yards. At Waterloo, the opposing armies being twelve hundred yards distant, were out of reach of all but solid shot from field guns, as they were then served. It is now stated that the Minié rifle is effective at a mile distant, and at two thousand yards troops can easily shoot each other. It follows, from these simple facts, that artillery must improve or become ineffective. The improvements in the rifle were mostly in the ball. The French pin rifle had a small steel "pin" in the bottom of the chamber. The powder filled in around this pin, and the ball, of a conical shape, hollow at the base like a thimble, had a small metal plate, which, on being rammed home, struck against the pin, and spread the ball so as to slug the piece. The Minié rifle was nearly the same, without the pin, because it was found that the explosion would of itself spread the ball. The performances of this weapon are somewhat marvellous, since it is

COLT'S

SPORTING RIFLE.



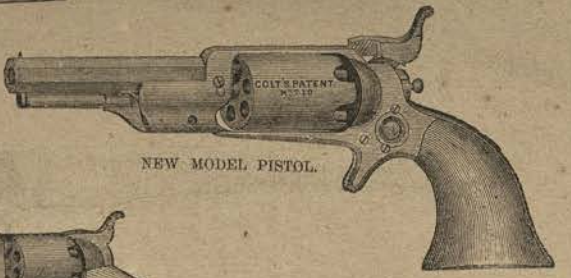
MILITARY CARBINE.

REVOLVING SHOT GUN.

MILITARY OR REGULATION RIFLE.

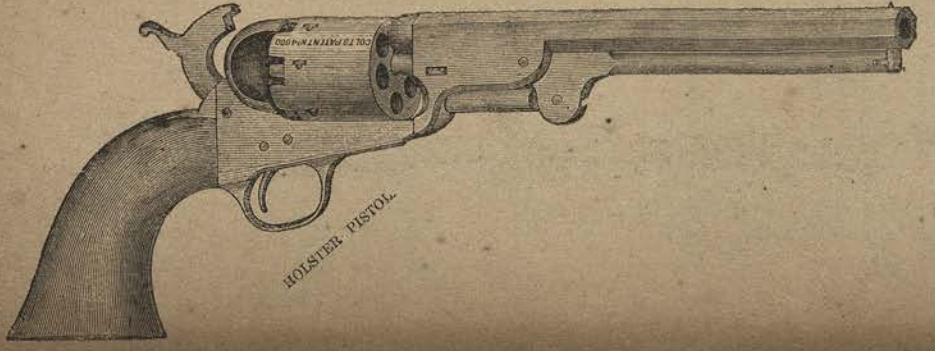
COLT'S

MILITARY RIFLE.



NEW MODEL PISTOL.

REVOLVING PISTOL WITH CARBINE
BREECH ATTACHED.



HOLSTER PISTOL.

SPORTING RIFLE.

said that it is effective at a distance of over a mile.

The most important improvement in small arms has, however, been in repeating weapons, of which the revolvers of Mr. Samuel Colt are the type. Mr. Colt was a seaman in his youth, and while on a voyage to Calcutta devised the revolver. He made the model in wood, in 1829, while at sea. Improving upon this, he took out his first patent for fire-arms in 1835. This was for the rotating chambered breech. This of itself was no new invention, since many of the old arms preserved in the tower of London have the same style of manufacture. It is obvious, however, that what is possible in this respect with percussion caps, was not so with the old flint-lock. Mr. Colt had the advantage of the cap, and his invention caused the chambers to revolve by the act of cocking. In 1851, he read an essay upon the subject before the Institution of Engineers in London. Patents were issued in France, England, and the United States; and in 1835 an armory was established at Paterson, N. J., but afterward abandoned. The first important use made of this new arm was in 1837, by the United States troops under Lieut. Col. (now Gen.) Harney. The Indians were acquainted with a "one-fire" piece, but when they saw the troopers fire six times without loading, they thought it time to give in. There was not much demand for the arm until the Mexican war of 1846–47, when a supply was required for Taylor's army. The government ordered 1,000, and there was not a model to be found. This order was filled at Whitneyville, near New Haven. Other orders followed, and the works were transferred to Hartford. Mr. Colt manufactured on his own account. The California fever set in, and was followed by the Australian excitement. The demand for arms thus occasioned, induced Colonel Colt to erect an armory unequalled in the world. It occupies what was a flooded meadow of two hundred and fifty acres. This is diked in for two miles, and the most extensive buildings have been erected, at a cost of $1,000,000, to supply 1,000 fire-arms per day. In 1858, 60,000 were turned out. All the accessories of these arms—balls, cartridges, bullet-moulds, powder-flasks, etc.—are manufactured at this place. There are also extensive works for the manufacture of the machinery by which fire-arms are made. It is to be remarked that at these works the machinery for the British government armory at Enfield has been made; and also all those for the Russian government at Tula. The arms of Colt attracted great attention at the World's Fair of London. "In whatever aspect the different observers viewed the American repeaters," says an account of the impression they made at the Crystal Palace, "all agreed that perfection had been reached in the art of destruction. None were more astonished than the English, to find themselves so far surpassed in an art which they had studied and practiced for centuries; by a nation whose existence was within the memory of man, and whose greatest triumphs had been in the paths of peaceful industry. The Duke of Wellington was found often in the American department, pointing out the great advantage of these repeaters to other officers and his friends; and the different scientific as well as popular journals of the country united in one common tribute of praise to the ingenuity and genius of Colonel Colt. The Institute of Civil Engineers, one of the most highly scientific and practical boards of its kind in the world, invited Colonel Colt to read a paper before its members upon the subject of these arms, and two of its meetings were occupied in hearing him, and in discussing the merits of his invention." He was the first American inventor who was ever thus complimented by this celebrated institute, and he received at its hands, for his highly able and interesting paper, the award of a gold medal and a life-membership. In addition to his presence before the institute, Colonel Colt, in high compliment to his experience and skill, appeared also, upon special invitation, before a select committee on small arms of the British Parliament, and there gave testimony which was gladly received, and deemed of superior practical value. His own statements were amply corroborated at the time, before the same committee, by British officers, and others, who had visited his armory in America; and especially by J. Nasmyth, the inventor of the celebrated steam hammer, who, in reply to the inquiry, what effect his visit to Colt's manufactory had upon his mind, answered: "It produced a very impressive effect, such as I shall never forget. The first impression was to humble me very considerably. I was in a manner introduced to such a skilful extension of what I knew to

be correct principles, but extended in so masterly and wholesome a manner, as made me feel that we were very far behind in carrying out what we knew to be good principles. What struck me at Colonel Colt's was, that the acquaintance with correct principles had been carried out in a bold, ingenious way, and they had been pushed to their full extent; and the result was the attainment of perfection and economy, such as I had never met with before." All tests and examinations to which the repeating arms were subjected in England, were highly in their favor. Emphatically they spoke for themselves. The enormous power—nay, the invincibility of British troops armed with them, was demonstrated. "The revolver manufactured by Colonel Colt," said the *Dover Telegraph*, a public journal, expressing the best and almost universal opinion of England upon the arm, "is a weapon that cannot be improved upon. It will, we unhesitatingly predict, prove a panacea for the ills we have so unhappily encountered in the southern hemisphere. The Caffre hordes will bitterly rue the day on which the first terrific discharge is poured upon their sable masses." And so a panacea the revolver did prove, both with the Caffre hordes, and with the Muscovite also, upon the bloody plains of the Crimea. Over 40,000 of these pistols are now in use in the British navy; and Garibaldi has been ably sustained by a corps commanded by Colonel Peard, and armed with Colt's revolving rifles.

The most important progress in the manufacture of these arms, is that each separate part of a pistol or carbine is made after one pattern by machinery, and with such entire accuracy, that a number of the weapons may be taken to pieces, and any part of one will fit any of the others. Each separate part is made perfect of itself, and separate boxes contain these parts. The weapons are put together rapidly when wanted. There has been a gradual improvement in them, from suggestions derived from their use in Mexico, the Crimea, and Italy. It is now a world-renowned weapon.

The great success of Colt has, of course, brought forth imitations, and repeating arms of many descriptions have been patented. Very many are infringements on Colt. There are Allen's, Derringer's, the Volcano, and other pistols, and Pettinger's patent, which is a revolving chamber, but also a patent lock of some reputation.

The invention of breech-loading weapons has also been very successful. The type of this class is Sharp's rifle, which was invented about the year 1852, by Mr. C. Sharp, of Philadelphia. The cartridge in this weapon is put in at the breech, and the "twist" removed by the act of closing the breech. The piece is also self-priming. The caps, instead of being single, in the shape of small thimbles, as usual, are made flat, and arranged together like the coil of a watch-spring; at each cock of the piece this uncoils and thrusts a cap, or one section of the coil, over the nipple. The danger of this is that they all explode at once if not well made. After the most careful examination of the construction of this arm by competent men, it was found, in comparison with others, to stand the tests of a first-class weapon, being safe and certain in firing, easily and rapidly loaded, simple in its construction, and constantly kept clean by its own operation. For sporting purposes, this rifle soon became a favorite weapon. The ordnance department at Washington expressed their admiration of the improvement; and subsequently the British government ordered 6,000 of these rifles, for the use of their army in India. More recently, Mr. Sharp applied the principle which distinguishes his rifles to the construction of a new pistol or carbine, especially designed for the use of mounted dragoons. The advantages claimed by the patentee for the new pistol are numerous; among others, that it is more compact, lighter, has a more extensive range, and fires with greater accuracy than any pistol now in use. It is single-barrelled, but owing to the ease with which it can be loaded, it is capable of being fired twice as often as any revolver in a given period of time. The pistol weighs about two and a half pounds; the barrels are six and eight inches long, and throw a half-ounce ball effectively one-fourth of a mile. It primes itself for twenty rounds. It was recently tested, in competition with various other fire-arms, at West Point, by a board of officers appointed by the United States ordnance bureau, and struck a target six feet square, at a distance of 600 yards, twenty out of thirty shots. The same pistol was fired seventy times in seven minutes, priming it three times, every ball striking a target three feet square, at a distance of forty-five feet, with a force sufficient to penetrate eight inches of pine board. Certificates from officers in the army

testify to the high estimation in which it is held by the troops that have tried it. The firm of C. Sharp & Co. erected (for the manufacture of his fire-arms) a very extensive establishment at the west end of the wire bridge, near Fairmount. The building is of brick, 140 feet long by forty feet broad, and is surmounted by a cupola, from which an admirable view of the city and surrounding country can be obtained. The machinery is of the most beautiful and accurate description: the entire cost for the buildings and machinery being about $130,000. The basement is used for the forging of the iron material of the pistol. In the rear of the first story is placed a high-pressure stationary engine of seventy-five horse power, which forms the motive power of the establishment. The second story is used for the boring of rifle barrels, which are drilled from solid cylinders of cast steel. The third story is the tool manufactory, where the cutting, milling, and finishing apparatus is constructed. The fourth story is the finishing shop, where the rude materials are adjusted, and from which the article issues complete. The manufacture of the rifles is carried on in Connecticut.

Among new inventions of breech-loading pistols is that of Stafford, of New Haven. The conical ball, as in the case of all breech-loading arms, is fixed ready for use in a copper cartridge, which is dropped from the left hand into the barrel when the pistol is held by the right hand. The barrel being attached to the stock by a hinge, is opened to receive the ball. Then, on throwing the barrel into line with the breech, by an upward jerk of the right hand, it is ready for use. There is a spring catch in front of the hammer of the lock which catches the barrel and holds it in position until the pistol is discharged. When the thumb is brought down on the catch, the barrel is disengaged, and, by a jerk, is thrown into position for reloading—the whole operation of loading and firing being accomplished in a small fraction of the time required to describe it. This must be so, for an expert can fire sixteen shots a minute with this pistol. The arrangement of sights is also complete, so that any object can be exactly covered by a marksman with precision, and the penetration and force with which the ball is projected can hardly be realized by those who have not experimented with it.

In the present year (1860) a patent issued for a breech-loading cannon, which has also been patented in France and England. By this a ball cartridge is dropped into the gun by an opening in the breech, a pin moves forward, pushing the cartridge, closing the hole by which it entered, and discharging the piece by percussion powder.

The rifle factory of Mr. Eli Whitney, situated at the foot of East Rock, on the Hartford and New Haven turnpike, was founded by the father of the present proprietor, in the year 1778, and was long used by him in the manufacture of arms for the United States government. This gentleman, distinguished for his talents as a mechanic, for his sound judgment, and for his persevering industry, applied to this branch of business the same skill and ingenuity, the first fruits of which had been already displayed in the invention of that instrument so important to the agricultural interests of the south—the cotton gin. The result was the production of an article superior to that obtained from England, not only in itself, but also in the manner in which it was made. The method of manufacturing muskets then devised by Mr. Whitney, and also many of the different kinds of tools invented and used by him, have been since adopted in the national armories. The establishment has, we believe, been exclusively devoted to this business from the time of its foundation until a few years since, when an alteration was effected, and the manufacture of rifles substituted. The metal is wrought into the most eccentric shapes, without any further intervention of human hands than is requisite for superintending the machine. Owing to this skilful arrangement of machinery, only thirty-five men are required to carry on the works, turning out nearly 3,000 rifles a year, worth about $13 apiece. In the manufacture of these about 50,000 pounds of iron, 6,000 pounds of copper, and from 4,000 to 5,000 pounds of steel are annually consumed. The steel is worked up into ramrods, springs, and portions of the lock. The iron costs about $140 per ton, and is obtained from Salisbury, Connecticut—that procured there being found of a superior quality to either the English or Pennsylvania iron. The stocks are made of black walnut, which is brought from Pennsylvania. The rifles, when finished, weigh ten and a half pounds each. A striking advantage gained by the extended use of machinery in making the different parts of the rifle is the perfect uniformity of the work. So accurately and

in so many different ways is every part, even the most minute, gauged, that in putting together the whole, no delay is occasioned from trifling inaccuracies in fitting. Each screw, spring, sight, top-board, or any other piece whatever, is so nicely wrought that it may be applied to and will fit any one of the 3,000 rifles made in the course of the year as exactly as it does the one of which it finally forms a part. The rifles are made on contract for the government, and are not offered for sale.

The manufacture of guns is extensively carried on in England, and the value ranges from $1.50 to $175 each. A vast quantity of the cheap arms has always been manufactured for the American trade, particularly for the Indians. The common guns are made of flat strips of iron, called a kelp, three feet long, four inches wide. This is rolled into a cylinder by hand, and the edges welded. Sometimes the strip is thick, and one foot long, being drawn out as it is welded. The quality of the gun depends upon the toughness and elasticity of the iron. A superior gun was made of the metal used for horse-shoe nails, and the old nails or stubs were reserved for this purpose, and formed a large item of import into England from the continent. Latterly they have been supplanted by iron made for the purpose. Steel bars in combination with iron ones, called laminated steel, are now thought to be the best. There is much fraud in this manufacture, and thousands of guns of common Damascus iron are imported into the United States as laminated steel.

The manufacture of guns is carried to great perfection at the United States armories at Springfield, Massachusetts, and Harper's Ferry, Virginia. The guns are there made of flat bars of iron 14 inches long, 5 3-8 inches wide, and 9-16 inch thick. The edges are bevelled, so that when turned over into a cylinder they will make a perfect joint. The bars are first put into a reverberatory furnace, and when at a white heat are passed through curving rolls, of which there are five, to bend the roll gradually in order that it may not split. The curving of 450 is a day's work. Before it is curved it is called a plate; after, a cylinder; when welded it is a tube, and a barrel when it receives its shape in the taper groove. The welding being completed, the foreman takes the barrel to the straightening machine. This revolves sixty times in a minute. The machines will weld seventy-five barrels per day. At every stop the tests of gauge and inspection are rigidly enforced. The barrels are proved twice, with 360 and 240 grains of powder, and a ball double the weight of the service ball.

The stocks are of black walnut, and are delivered by contract in the rough. They are turned into perfect finish in half an hour, passing through sixteen machines of the principle of Blanchard's lathes. The "furniture" or metallic mountings for receiving the barrel and stocks, are most of them stamped out of plates.

The locks are highly ingenious, and brought to great perfection. They are too complicated for description. In the year 1859 the government produced 20,000 muskets in both armories. The United States rifle musket is composed of eighty-four different pieces, twenty-six of which are of cast steel, two of wood, and the remainder iron. There are 524 distinct operations performed on each musket and appendages. Each operation has a fixed price.

The improvements in small arms have been more successful than those in cannon, although the subject has for a long time occupied the serious attention of governments and scientific men. The military maxim, that "he who would live long must enlist in the artillery," seems likely to lose its point. That arm was always effective out of musket range, but now, as we have seen, its fire falls short a long way inside of rifle practice. In recent years, there have been attempts to form guns of wrought iron, commonly of hoops encasing bars of the same metal. This construction was adopted for the first cannon, and was returned to in the formation of the Stockton gun, which weighed 7 tons 17½ cwt., the explosion of which killed some members of the cabinet in 1845. It was a gun of the same nature, the explosion of which killed James II. of Scotland, in 1460. The efforts that have been made in this direction abroad have produced many new guns. Among these the Lancaster, which was to have had such effect in the Crimea. The gun has a twist, and the oblong ball moves endwise through this twist, giving the gun an immense range, but it was very uncertain of aim, and each discharge cost one hundred dollars. Many of these burst with great damage. This was supposed to be owing to the wedging of the shot in the twist. The new rifled guns of Armstrong, Eng-

lish, and those of the French invention, have not yet been sufficiently proved, although it was said that the latter were of great influence in deciding the Italian campaign. The greatest decided improvement in guns, however, is an American one, by Captain Dahlgren, of the United States navy. That gentleman entered the navy in 1826, as a midshipman, and was made commander in 1855. Since 1847 he has been employed in ordnance duty, conducting experiments that have had great results. Among these is the adoption for boats of bronze howitzers, 12 lbs. and 24 lbs. calibre, to throw shells, shrapnell, and canister; they are also available on land. The Dahlgren gun is considered the most perfect form yet constructed, and the new steam frigates are armed with them. The length of a 10-inch Dahlgren is 107 inches, and the range 1,776 yards. The improvement in the United States in the manufacture of guns is still making progress.

The best metal yet used for guns is cast iron. That metal was, however, formerly not so well made as at present. It was not so uniform in character, and its strength was estimated at 20,000 lbs. the square inch, while bronze burst at 33,000 lbs., and was thought to be more relied upon for uniformity. This opinion has been modified by experiments, made by Major Wade, of the United States army, at Chicopee, in Massachusetts, in 1850. It there appeared that samples from different parts of the same gun showed a difference of from 23,108 to 54,531, showing a tendency of the metal to cool in masses into separate alloys. Bronze was, however, less hard than iron, and its great cost caused it to be confined to field pieces, while for every thing above iron is used.

The casting of guns was originally hollow, but from unequal contraction in cooling, caused by different temperature within and without, the plan was abandoned, and the gun being cast solid was bored out cold. In the United States, experiments have been successfully made to improve the qualities of iron for gun purposes. The object is to produce a metal of a perfectly uniform texture, hardened with the piece to prevent the battering action of the ball. The principle of strengthening iron by remelting was developed in experiments carried on by Major Wade, of the United States army. Since 1841 an officer is required to be present at the foundries while cannon are making, to examine and test the metal before it is used, as well as the first gun made, before another is cast from it. This inspection has been highly useful. The transverse strength of some iron was found to be doubled by four meltings and castings. From experiments made at South Boston in 1844, it was found that the cohesive power of iron is augmented by exposing the melted iron to intense heat. This is increased by the time of exposure, up to a limit beyond which the strength retrogrades. All the experiments resulted in increasing the average strength of iron from 23,638 lbs. to 37,774 lbs. the square inch. The strongest piece of iron ever cast was a sample of Greenwood (Orange county, N. Y.) ore. It was brought to the degree of density which is combined with the greatest strength. In the sample the density was 7.304, and the tenacity 45,970 lbs. per square inch. This material will be probably the favorite for gun manufacture.

The process of casting bronze guns is complicated. The pattern of the piece is prepared by taking a tapering rod much longer than the gun, and enclosing it entirely in the coils of a soft rope. When this has approached the form of the intended gun body (not including the breech), it is laid over with plaster-of-Paris. It is then caused to revolve against a profile board, and by so doing receives its shape. The models of the trunnions, or arms on which the gun rests on its carriage, are then attached to it, and the whole dried. It is then washed with ashes to prevent adhesion, when it is covered with putty loam dried hard. This is the first layer of the mould, and other layers are added, until the whole is $2\frac{3}{4}$ inches thick. This mould is then encased in iron bands, over which a further thickness of 5 inches of mould is laid. Over this come more hoops and mould. The rod, with its covering of rope and plaster, is then taken out, leaving the putty mould entire. The breech mould is made separate in the same manner, and that for the "head" also. When thoroughly dried, the three sections are set up in the pit with several others, and the spaces around are rammed in with earth firmly. In order that the metal when running in may settle as equally as possible, it is introduced at the bottom. It thus rises in the gun, and into the head three feet above the gun. The object of this head is to allow the metal most likely to be imperfect to rise to the top. Hence,

when the gun is cool, this head is cut off. The gun is then solid, and, being placed upon a frame, is bored out. In this case the borer does not revolve, but the gun itself. A steel cutter, fixed to the end of a bar, penetrates into the gun as it is made to revolve against it, being pressed up to it as the work progresses. The boring being finished, the gun is turned, and the touch-hole drilled with a bit and stock.

In casting iron guns the process varies slightly. The mould being prepared, is enclosed in a huge case of cast iron, called a gun box, made in sections. The lower section contains the mould of the breech, and is entire. Between the mould and the sides of the case, sand tempered with clay is rammed. The flat surface on which the next section is to rest, is covered with fine charcoal and clay water to prevent adhesion. The second section is of two pieces divided lengthwise, and has affixed to it the trunnions. The mould is kept in a perfectly vertical position by being adjusted by a plumb line. Sometimes the space round the box is left empty, and covered over to retain the hot air and prevent cooling too rapidly. When the mould is ready, the iron, which has been prepared by many remeltings, flows from several furnaces, through channels in the sand, into a reservoir, from which runners or channels lead over the tops of the moulds, which are slowly and steadily filled, without the introduction of air to disturb the quiet settling of the metal.

The guns being cast, the difficulty is in cooling them to preserve the uniformity, and fires are sometimes kept burning round the case for several days after casting. At this point, an important improvement was introduced by Lieutenant Rodman. The original mode of casting guns hollow was abandoned for boring in 1729. On the plan of Rodman, guns are now cast hollow. A water-tight tube of cast iron is placed in the centre of the mould. In the centre of this tube is a smaller one, and through this a current of cold water enters, and, rising in the larger tube, flows off. Thus the interior is cooled, while the exterior is prevented, by heated air, from cooling too fast. The metal is thus protected from unequal contraction. In proof of this experiment, guns were cast in pairs. These were 8-inch bores, of the same iron in every respect, one solid and one hollow. The solid gun burst at the seventy-third discharge. The hollow one stood fifteen hundred, and did not fail. A pair of 10-inch guns, treated in the same manner, resulted in the bursting of the solid gun at the twentieth fire, and the hollow one at the two hundred and forty-ninth.

Another curious fact was substantiated, viz., that the strength of the gun increased by time. 8-inch solid cast guns, proved in 30 days, stood 72 charges; one proved in 34 days stood 84; one in 100 days stood 731 charges; one that lay six years stood 2,582 charges. The explanation of Major Wade was, that the particles of iron strained in cooling by unequal contraction, readjust themselves in time, and reach their greatest tenacity.

When the iron gun, whether cast solid or hollow, has been dressed and drilled, it is ready to be proved, which is done in this country by testing the strength of a cylinder of the iron an inch in diameter and two inches long, cut out of the cannon, formerly from one of the trunnions, but now from the barrel near the muzzle. The specific gravity and other properties of the sample are carefully noted, and these, together with the trials to which it is subjected, and the hardness of the metal determined by a very exact method, give correct indications of the strength of the gun, without the necessity of submitting it to extreme proof by firing with constantly increasing charges until the piece is destroyed. Indeed, to such perfection have these proofs been brought, that guns have been selected as of inferior quality from among a large lot, which, on reference to the books of the foundry, were found to have been the only ones of the lot made of hot blast iron. According to the indications furnished by the tests, several guns are usually taken from each large lot of them, to be submitted to extreme proof—the selection being generally of those that appear to be the poorest, best, and intermediate qualities. These are fired commonly with charges of powder equal to one-fourth the weight of the ball, with one shot and one junk wad over it. The firing is continued, unless the piece previously bursts, to 500 rounds. Then one ball more is added with every discharge, till the bore is filled. The powder is afterward doubled in quantity, and the bore filled with shot at each discharge. When it bursts, pieces are selected for further examination from the breech, near the trunnions and the chase. Guns are also tested by hydrostatic pressure, water being forced into the bore

with increasing pressure, till it sometimes bursts the piece, or brings to light its hidden defects by opening the small fissures that were concealed in the metal. It is not uncommon for it to appear upon the exterior of pieces, of which the thickness of the metal is four inches, exuding through as a thin froth, which collects upon the outside, and forms drops and little streams. By this method, the exact pressure applied is known, and may be gradually increased to any desired degree. Sample bars are also cast together with the cannon, which furnish some indication of the strength of the metal. The different rates of cooling of the large and small mass, however, render their qualities somewhat dissimilar.

The next hostile operations upon the ocean will have to encounter countless changes that have been made since the last war. Steam will develop its yet untried powers in warfare. The new armor to make ships ball-proof, the range of small arms, and, not the least of the new agents, the effect of the shell guns of Dahlgren, are to be tested. The difficulty of gettting to close quarters is by them much increased. The picking off of officers and men by the use of the new rifles must have the same tendency. In naval gunnery, as on land, the small arms formerly came into play only within the range of the batteries. At present, the small arms are first effective, and the Dahlgren only recovers a portion of the ground lost by cannon as a consequence of the increased range of rifles.

In 1848 also commenced in our navy, under the direction of Dahlgren, the adaptation of graduated scales to naval guns. These bear the ranges in yards, and elevations in degrees and fractions. Tables containing the angles of elevation answering to different distances, are furnished in the "Ordnance Manual." The scales are made of brass, and fitted to the breech of the gun. These insure accuracy of aim.

An interesting series of experiments has been conducted, under government orders, by Major Mordecai at Washington, in relation to the initial velocity of shot. By initial velocity is understood the velocity of the shot in the gun after discharge. This is considered the most important point, and infinite pains and expense have been incurred in deciding it. The experiments made by Major Mordecai were in this view. The machines used for this purpose are a block filled with sand suspended on iron straps, at fifty-five feet distance from the gun, which is also suspended. At the discharge the gun recoils, and its rate of recoil is measured, while the shot buries itself in the sand contained in the block, imparting a motion, which is also measured. The weight of the block is 9,358 lbs., and of the gun pendulum 10,500 lbs. The result of a great variety of experiments was, that the velocity measured by the block was nearly the same as that measured by the gun.

The deductions from the experiments were some very valuable conclusions concerning the charges for cannon and small arms, and the form of the cartridge for heavy guns. In relation to wad, it was decided that the use of hay or punk is injurious to correct aim. When a wad is required to hold the ball, it should be light. In small arms, on the other hand, wad is required to develop the force of the charge; unless, as in the case of the rifle, the ball has no windage.

Another description of gun has been made up and experimented upon at Old Point Comfort. This tremendous piece of ordnance, by far the largest ever cast in this or any other country, is designed for use in our coast defences, as an offset to the late important improvement in the construction of vessels-of-war. It is intended to cripple, certainly and hopelessly, at a single shot, any hostile ship or steamer, no matter how large or strongly built, that may venture within a mile of its enormous muzzle.

The Floyd gun was cast but a short time since, at the Fort Pitt foundry, near Pittsburg, Pennsylvania, under the supervision of Captain Rodman, of the ordnance department. It weighs, independently of the carriage, 49,099 lbs., and its cost is something over $10,000. The bore is sixteen inches in diameter, and fifteen feet in depth. The gun is worked by six men, and the time consumed by loading and firing is just one minute and a half. It will throw either shot or shell; and these are spherical in form and of appalling magnitude—the solid shot weighing 450 lbs. The 15-inch shell weighs about 384 lbs., and carries beside 15 lbs. of powder. The charge of powder used in firing this monster cannon was at first only 20 lbs., but this has been gradually increased to ascertain the maximum of powder; and in the last discharge no less than 45 lbs. were used.

The piece is not intended to be fired at a longer range than about two thousand yards, but at this distance its execution is terrific, completely shattering the most massive targets, whether constructed of stone, timber, earth, or iron.

Not the least singular feature of the big gun is the powder used in discharging it. The grains are hard, smooth lumps of irregular shape, varying in size from half an inch to an inch in diameter.

There was convened in August, at the fort, a board of engineers, commissioned by the government, to examine into the expediency of introducing the Floyd gun as a regular arm of the United States service.

Among others present, was an officer of the Russian army, who appeared to take the deepest interest in the success of the gun, doubtless with a view of ultimately introducing it into the service of the czar.

CUTLERY.

UNITED STATES INDUSTRY—AXES.

The manufacture of cutlery in the United States is of recent origin comparatively. But a few years since, the whole supply came through the hands of the importer from Europe; but the production of edge-tools and cutlery was no sooner started, than it took a rapid growth; and a foreigner, remarking upon branches of American industry, says: "The manufacturers of cutlery have far surpassed those of the old world in the production of tools, and that not merely in the excellence of the metal used, but especially in the practical utility of the patterns, and in the remarkable degree of finish in their work." This is a just remark. The "high finish" of American work is applied only, however, where it has utility; not where it is a useless expense. This may be illustrated in watches and clocks. The English have highly polished works, that add much to the expense, but nothing to the service. In the American article this expense is saved. A peculiarity of American work is the readiness with which improvements are perceived by the intelligent worker, and immediately adopted and applied. This intelligence comes, in some degree, from the entire freedom of industry, and the absence of all trade "guilds," unions, or restrictions. The American who travels in Europe is struck with the, to him, ludicrous mystery with which every species of handicraft is surrounded. It would seem as if the proprietor of every petty workshop or factory was exclusively possessed of the philosopher's stone, which would be robbed from him by the prying gaze of every transient visitor. The apprentices are only taught the routine of centuries, and only so much as is necessary to fulfil the part of the labor required of them. The manufacture itself, whatever it may be, is divided into branches, each of which is in charge of persons who preserve their supposed secret from the other branches. Under these circumstances, the apprentice succeeds with difficulty in becoming a master of his trade. When out of his time, he must travel for three years; and when he returns to his native town, he must have money and interest to be made a citizen, and then admitted as a member of the guild, or trades' union, before he can pursue, except as a journeyman, the trade he has learned. How different is all this in the United States! The boy enters a factory, or a workshop, and is taught his especial work, and has within his reach every branch of information, scientific and practical, connected with the whole of it. His fellow-workmen are experienced in all the branches, and with the best modes in use in all countries. His employer is wedded to no system or rule, but is ever on the alert for improvement; always ready to suggest and hear suggestions, and to adopt feasible ones. It is no wonder that, in such an atmosphere, the arts should flourish, and that an observant foreigner should exclaim, as above, that hardly twenty years of experience in the new world should have surpassed the centuries of progress in the old world. This branch of industry thrives mostly in individual workshops; it has not come much within the sphere of corporate influences. There is a general and very perceptible adoption of American patterns, not only in Europe, but in England, as being more practical; and it is stated, that in American factories already, there is more English steel used than in England itself. The American worker does not believe in using poor tools, when good ones are to be had.

Steel is the material used, by reason of its hardness, for the cutting edges of tools and cutlery. The backs are made of iron, as a cheaper material. So also are the handles, or "tangs," to which the steel is welded. The steel is blistered, as, or after, it is drawn down, by tilt-hammers, into shear-steel. This is used for table-knives, scythes, etc. When

a fine finish is required, or great hardness, the blistered steel is melted into cast steel, and the ingots are forged into bars. Simple articles, such as chisels, are made by hammering a bit of cast steel into the required shape. This being intended only for the edge, is made very thin, and upon it is welded a flat slip of iron, which has been forged into the shape of the chisel, with a shoulder formed by driving it into a hole in the anvil. One side of the chisel is, therefore, iron, intended to be ground away, and the other steel. Scissors are made of various materials. Common ones are shear steel, with the blades hardened. Tailors' shears have the blades only steel; the remainder is iron. Formerly, only the edge was steel. Some scissors are made of good cast iron, called run, or virgin steel. Of these, many are sold for 7 cents a dozen. There are some, on the other hand, made with bows and shanks of gold, and sell for $50 a pair. When made wholly of steel, the blade is hammered out at the end of a small bar. It is then cut off, with enough to form the shank and bow. A hole is then punched; the instruments shaped, united by a screw, ground, filed, and burnished. The blades are slightly bowed, in such a manner that they touch each other only at the point of cutting, and this point moves as the blades close in the act of cutting, from the pivot to the point. This operation is seen by holding a pair of scissors, edgeways, to the light. This action gives smoothness to the cut.

The manufacture of table cutlery is of recent introduction into the United States; and it has made progress, by reason of the American invention of a machine to form the blades, which invention has been adopted in Europe. In the old process, the blade of a table or other large knife is hammered out on an anvil at the end of a bar of steel, and cut off. It is then welded on to the bar of wrought iron, about half an inch square, and enough of this is cut off to form the bolster, or shoulder, and the tang. The blade is then heated and hammered, or, as it is called, smithed, which serves to condense the metal, and enable it to acquire a higher finish. The mark of the maker is then stamped upon it, and it is hardened by heating to redness, and plunging it into cold water. It is tempered to a blue color, and is then ready for grinding. The small blades of pen-knives are hammered, entire, out of the best cast steel. A temporary tang is drawn out, to secure the blade while it is ground. A number of blades are heated together for tempering, by being placed over the fire, upon a flat plate, their backs downward. When at the proper degree of redness, so as to take a brown or purple color, they are dipped in water up to the shoulder. For razors, the best cast steel is selected; and when the blade is shaped upon the anvil, from a bar as thick as the back of the razor, and half an inch wide, it is well smithed, to condense the metal. Only the best metal will bear the working down of one part of the blade to the requisite thinness, while the back is left thick. The shape is further improved by grinding on a dry, coarse stone. The tempering is performed after the blade is drilled for the pin of the joint, and stamped. It is then ground and polished.

The grinding and polishing of cutlery is conducted mostly by wheels constructed for the purpose. There is a trough, with a stone for grinding, and a polisher, driven by a pulley. The stones vary in diameter from 4 inches to 2 feet, according to the articles to be ground. The convex surface of the small wheels gives the concavity on the blade of the razor, and the other wheels suit the various sizes and shapes of the articles polished. Some are used dry, and others are kept wet, in order that the heat engendered by dry grinding may not injure the temper of the articles ground. The dry grinding is more expeditious; but, unless the troughs are furnished with a ventilating fan and flue, for carrying off the fine metallic particles and dust from the stones, the health of the worker suffers. This flue is constructed of tin, in the shape of a sort of cap, that comes over the back of the stone; the other end of the flue is in an adjoining room, and has the air partly exhausted from it by a fan in rapid motion. This creates a strong current, which, when the stone is in operation, carries the dust and filings from it into the flue. When the grinding is completed, lapping succeeds. This is done on a thin wooden wheel, faced with a tire of metal made of five parts lead to one of tin, and cast upon the edge of the wheel. It is then turned true, and indented, so as to hold a dressing of oiled emery of different degrees of fineness. The steel blades receive various degrees of polish, by drawing them from end to end across the revolving lap, which is fed with emery of various sizes.

The handles of cutlery are made of a variety of substances: ivory, horn, mother-of-pearl, tortoise-shell, cocoa-nut, maple-wood, etc. Ivory is mostly used for table-knives. A solid piece is cut out, of the right size, and a hole for the tang bored at one end. This is sometimes carried through, so that the tang may be visible. When it does not go through, the tang is secured by cement. By a late contrivance, a little spring-catch is fastened to the tang, which falls into a notch made in the cavity of the handle, and prevents it from being withdrawn. Balance handles are made by introducing lead into the handle, to counterbalance the weight of the blade. The handles of pen-knives are complicated. The springs must be nicely adjusted, requiring a peculiar temper. The slips for the handles require great care in the fitting. It is stated that a three-bladed knife passes through the finisher's hands one hundred times.

The manufacture of butcher and shoe knives is large in the state of New York. The state census of 1855 gave it at 35,000 per annum; and these have a wide reputation.

The manufacture of forks is said to be one of the most unhealthy of the mechanical arts. It has been estimated that the destruction of life in it is greater than in any other pursuit, by reason of the fine dust evolved in the process of grinding, and which fills the atmosphere of the rooms, and invades the lungs of the operators. This takes place in the finishing. The forks are hammered out of square steel rods, 3-8ths of an inch thick. The tang and shank are roughly shaped at the end of the steel rod, and are then cut off, with about an inch of the square steel besides. This is drawn out flat for the prongs; and the tang and shank are then shaped by the die. The other end, heated to a white heat, is laid in a steel die upon an anvil, when another die, attached to the under face of a heavy block of metal, is allowed to fall upon it from a height of 7 to 8 ft. The prongs are thus shaped, and all, but a thin film of steel, removed from between them. This is cleared out by an instrument called a fly press. A number of forks are collected together, and annealed by heating and allowing them to cool slowly. They are now sufficiently soft to be easily shaped by the file, and by bending. They are then heated to redness, and suddenly cooled, by which the hardness is restored. The process of hardening renders all steel brittle; and it is intended to remove this, by tempering. The higher the heat when the metal is hardened, the softer and stronger will be the steel. A lower degree of heat gives more hardness, and also more brittleness. The temper is indicated in the color, and the temperature which produces that color follows a regular scale. Thus, 430 degrees of heat give a very pale straw color, suitable for the temper of lancets. Higher degrees of heat give darker shades of yellow, suitable for razors, pen-knives, and chisels; until, at 500 degrees, the color is brown-yellow, adapted to axes and plane-irons. Twenty degrees higher, the yellow has a purple tinge, seen in table knives. Thirty degrees more, and the dark color of a watch-spring is obtained. Again twenty degrees, and the dark blue of saws is visible. At 630 degrees, the color has a tinge of green, and the steel is too soft for instruments. This color is supposed to be produced by the action of the oxygen of the air upon the carbon of the steel, and protects the metal from rust in some degree.

One of the most necessary tools for a new and agricultural country is the axe. The remains of all lost races generally disclose, in some rude form, that useful instrument; and the modern nations of Europe present it in an improved metallic form. The Spanish axe, which has no head, is made by hammering out the bar, and turning it into a loop, to make the eye. The manufacture of the axe has, however, like its use, been carried to its highest perfection in the United States. An American axe has a fame coextensive with that of an American backwoodsman, who alone, of all the nations that visit this continent, is fitted to struggle with the mighty forests with which the country was covered. While the American pioneer, axe in hand, boldly buries himself in the forest to clear and subdue it, the European keeps rather to the plains, as more easily managed. The experience in the use of the axe, and the various uses to which it is applied, have combined to produce great varieties, all of which have undergone continual improvements. Formerly, the operator depended upon the rude forges and limited skill of blacksmiths to supply axes. With the improvements that suggested themselves, special factories sprung up, and the largest factory of the kind in the world is in New England. There, 1,200 tons of

iron, and 200 tons of cast steel, are by machinery wrought annually into tools. In the most recent process, hammered bar iron is heated to a red heat, cut of the requisite length, and the eye, which is to receive the handle, punched through it. It is then reheated, and pressed between concave dies, until it assumes the proper shape. It is now heated, and grooved upon the edge, to receive the piece of steel which forms the sharp edge. To make the steel adhere to the iron, borax is used. This acts as a soap to clean the metal, in order that it may adhere. At a white heat, it is welded and drawn out to a proper edge, by trip hammers. The next process is hammering off the tool by hand, restoring the shape lost in drawing out; it is then ground, to form a finer edge. It is then ground upon finer stones, and made ready for the temperer. The axe is now hung upon a revolving wheel in a furnace, over a small coal fire, at a peculiar red heat. It is cooled, successively, in salt water and fresh water, and then tempered in another furnace, where the heat is regulated by a thermometer. It is then polished to a high finish, which will show every flaw, and enable it to resist rust. It is then stamped, and the head blackened with a mixture of turpentine and asphaltum.

The manufacture of scythes has reached a high state of perfection in the western states, and the patterns have been imitated to a great extent in Europe.

The manufacture of surgical instruments has become large in the cities, mostly in Philadelphia, where the manufacture has acquired much celebrity. The ingenuity and skill with which an infinite variety of instruments are adapted to the purpose of operations upon the living fibres of the body, are marvellous in their way. The quantities supplied to the west and south are large.

The production of cutlery and edge tools in the Union, according to the census of 1850, was as follows:—

Number of factories	401
Hands	4,275
Capital	$2,321,895
Cost of labor	1,420,844
Cost of material	1,439,462
Value produced	3,813,241

This was for the year 1850. The quantities that are exported from the United States are small, not amounting to above a few thousand dollars. The imports, however, continue to be large. In the year 1857, they reached $2,140,000; of which, $1,953,396 was from England. The quantity imported is far from keeping pace with the number and wealth of the population. The great demand from the latter is supplied by the increasing home production of individual operatives.

FURS AND FUR TRADE.

Among the natural products of the new world, the valuable furs of the various wild animals which peopled its boundless forests, its rivers, lakes, and seas, were soon appreciated by the early discoverers and explorers. For many centuries the choicer varieties of fur had been held in the highest estimation, and the use of such as the ermine and sable was monopolized, by special enactments, by the royal families and nobility of both European and Asiatic countries. A market was therefore ready for the large supplies which were soon furnished to the early settlers by the Indians in exchange for the trinkets, liquors, and numerous articles of trifling value brought from Europe for this trade. The English and French competed with each other to secure the control of the business around Hudson's Bay and in the territories now constituting British America, extending from the Atlantic to the Pacific. Each nation established its own trading posts, or "factories," and protected them by forts, and the possession of these often passed by conquest to the rival party. The incorporation of the Hudson's Bay Company in 1670, by Charles II., gave a decided stimulus to the English interest, by securing to men of great influence and wealth, the control and monopoly of the fur trade throughout the possessions claimed by the British. The enormous profits realized by this company induced the Canadians, in the latter part of the last century, to form another company, which they called the North-west Fur Company, and whose field of operations was nominally limited to the territories ceded to the English by the French in 1763. Early in the present century their factories were extended westward to the rivers that flow into the Pacific, and they employed of Canadian voyageurs and clerks, who were mostly young men from Scotland, about 2,000 persons. They acquired possession of Astoria, at the mouth of the Columbia, in 1813, and vigorously competed with the old company—the two associations carrying on open war throughout the wild territories known only to these fur traders and the Indians they controlled. By act of parliament, the two companies were united in one in 1821, and their operations have been continued under the name of the Hudson's Bay Company until 1859, when their last special license of 1838 expired. The company has exercised a despotic sway throughout the territories it occupied, compelling the labor of the poor French voyageurs and the Indians, and causing them to subsist upon the most meagre fare and pitiful allowance. Sad tales of their sufferings are familiar to those who have visited these northern regions. The company established an express by the way of the great lakes and the western rivers, and by numerous relays, always ready, information was conveyed by canoes and by land travel in an incredibly short time from the head-quarters of the company at Montreal to the most distant posts on the Pacific. Their furs collected on both sides of the continent were transported to London for the great annual sales of March and September. From London many were sent to Leipsic, for the great annual fair at this famous mart.

While these extensive operations were in progress, the inhabitants of the provinces now constituting the United States derived little or no benefit from the trade so long as they remained British colonies. In 1762, an association was established among the merchants of New Orleans, for conducting the fur trade in the regions on the waters of the Missouri and its branches; and this led to the founding of St. Louis in 1763, by Laclede, the leader of the organization. This place was made their head-quarters for the reception of furs collected by their voyageurs in distant excursions by canoes and Mackinaw boats toward the Rocky Mountains, among tribes of Indians who often attacked their parties, but who, controlled by the talent and wise policy peculiar to the French, became at last firm friends of the enterprise, and bound to the interests of the Chouteaus and others by whom it was conducted. From St. Louis the peltry was boated down the river to New Orleans, or up the Illinois

to Lake Michigan, and thence to the great trading post of Mackinaw. From this it was forwarded by the lakes and the St. Lawrence to Quebec, to be shipped to England. Over the same routes were returned the groceries, etc., for the supply of the traders, which, so slow were the means of transportation, were the returns in part of the furs collected the fourth preceding year. But though the expenses of the long voyages more than doubled the cost of the supplies after they left Mackinaw, the profits of the business were not rated at less than 300 per cent. For fifteen years preceding 1805, the annual value of the peltry collected at St. Louis is stated to have been $203,750; and the value of the goods annually sent up the Missouri during about the same period was estimated at $61,000. Deer skins constituted the greater portion of the product, and they were, indeed, the chief medium of exchange, the value of articles being rated at so many shaved deer skins. Beaver and otter were the next in importance, and buffalo skins, which are now the chief object of the trade, were then scarcely collected at all.

From the year 1818, the fur trade of the north has been conducted almost wholly by organizations which have sprung from these early operations. It was extended by the associations established at St. Louis to the regions beyond the Rocky Mountains, and there carried on at immense sacrifice of human life, from the dangers naturally incident to the pursuit, and the unappeasable hostility of the savage tribes. In 1847 it was estimated that the annual value of the trade had averaged for forty years from $200,000 to $300,000, and the latter portion of this period much more than the larger sum named. But, like the discovery of gold in California, its greatest importance was the opening of uncultivated territories to the advance of civilization, and the introduction of a permanent population for the establishment of new states.

During the last century the fur trade had attained to no importance in the eastern states. Mr. John Jacob Astor, of New York, engaged in it in 1784, buying in Montreal and shipping to England. But under the treaty of 1794 he was enabled to introduce fur from the British provinces into New York, and he then opened a new trade direct with foreign countries, shipping peltries even to China, and receiving in exchange the rich products of the East Indies. As his operations prospered, he engaged in the early part of the present century in the collection of furs along the northern frontier, a field which had before been in exclusive possession of the North-west and Hudson's Bay Companies; and he labored zealously in the great national enterprise of diverting this important trade from the exclusive control of foreign companies, and causing it to contribute to the commercial interests of the United States. With wonderful energy, and dependent almost solely on his own resources, he carried on these gigantic operations, having in 1808 a capital of no less than $1,000,000 invested in them. In 1810 he established the Pacific Fur Company, for the purpose of forming a settlement on the Pacific coast, and by means of it carrying out the grandest commercial scheme that had ever been undertaken. His ships, leaving New York with supplies for the colony, were to obtain from it and by trading along the coast cargoes of furs to be sold in China, and there loading with teas, silks, etc., would return to New York, making a complete circumnavigation of the globe. Mr. Astor was bound by his articles of agreement to furnish capital to the amount of $400,000 if required, sending each year an expedition around by sea and another across the country to the mouth of the Columbia, and the profits were to be equally divided between his associates and himself. Notwithstanding a succession of disasters, Mr. Astor continued for three years to despatch a ship bound around Cape Horn, to the mouth of the Columbia, having unshaken confidence in the final success of the enterprise. And such, no doubt, would have been the result, had not his principal Canadian partner, who controlled the affairs at Astoria (the settlement on the Pacific), proved treacherous and given up the post to the rival North-west Fur Company for a mere nominal price, on the pretence that it would certainly be seized by the British cruisers during the war. This occurred on the 16th October, 1813.

From that time the operations of Mr. Astor were restricted to the northern territories lying east of the Rocky Mountains. His factories were at Mackinaw, and at the foot and head of Lake Superior, upon whose waters he maintained sailing vessels long before they were visited by the explorers of copper mines. Up to the year 1845 the only business prosecuted upon its distant

shores was that of the fur hunter, and they were, in fact, known only to this class and to the wandering Chippewa and Sioux tribes of Indians. The territory of Minnesota, also, and the still more western regions, were frequented only for the same object previous to 1848. From that period, or even earlier, the fur trade has declined in importance, and its profits have been divided among larger numbers of adventurers. The house of Pierre Chouteau, jr., & Co. has been distinguished for many years as the most enterprising of those engaged in the trade; and in 1859 one of their steamboats ascended the Missouri river to the Great Falls, near the Rocky Mountains, about 3,950 miles from the Gulf of Mexico, and returned laden with buffalo robes. Thus the trade still continues to be the pioneer of civilization—opening new roads into wild territories for the advance of permanent settlers.

At present, St. Paul, in Minnesota, is the chief trading post of the fur trade of the United States. Until the year 1844, the furs from the valley of the Red River were sent to Hudson's Bay by Nelson's River, but from that period they have been collected at St. Paul, whence they are transported down the Mississippi, and are brought at last to New York. In 1857, the value of the furs shipped from St. Paul was $182,491; and in 1858, when the price of furs was lower, the shipments amounted to $161,022. The following table exhibits the varieties and value of the exports of 1856:—

Animals.	No. skins.	Value.
Muskrat	64,292	$11,572 56
Mink	8,276	18,621 00
Marten	1,428	3,570 00
Fisher	1,045	4,702 00
Fox, red	876	1,095 00
" cross	20	100 00
" silver	8	400 00
" kilt	2,542	1,271 00
Raccoon	3,400	2,550 00
Wolverine	2,032	3,048 00
Otter	405	1,417 50
Beaver	586 lbs.	881 00
Bear	610	6,100 00
Lynx	50	125 00
Buffalo robes	7,500	41,200 00
Total value		$97,252 56

From this table it is apparent that the character of the important furs has greatly changed since the early periods of the trade. Buffalo robes, then esteemed of no importance, are now the largest and most valuable item; while the beaver and otter, and even the marten and fisher (two animals of the sable kind) have greatly fallen off in relative importance. The skins of some of the smaller animals, as the mink, assume the greatest importance for their numbers and value, and next to these, in aggregate value, are the skins of the common muskrat. The highest-priced furs are the Russian sable, the sea-otter, and the black or silver fox. For its size, the first named of these is the most valuable, but the sea-otter brings the highest price of any single skin. This is collected chiefly on the American and Asiatic coasts of the North Pacific ocean; and its greatest demand is among the Chinese and Russians, though its use by the former is restricted to the mandarins and high officers of state. In the latter part of the last century it was in such demand, that several expeditions were fitted out from this country, and also from Europe, expressly for collecting this fur from the islands and coast about Nootka Sound. The present value of the skins is from $100 to $125 each. The silver fox is found in the northern part of this continent, and is occasionally captured in the region about Lake Superior. The value of the skin is even greater than that given in the above table—being often rated at $60 apiece; in Europe, when well dressed, they have been known to bring nearly as many guineas. They are in demand chiefly by Russian noblemen for their most costly outside garments. Of late years the skins of the skunk have been largely collected, and thousands of them have been annually exported from New York. Those of black color were worth the most, and sometimes brought seventy-five cents each. The demand, however, has fallen off, as it is found impossible to entirely remove the disagreeable odor of the animal, so that it will not be given out when the articles made of the fur are moderately warm. Rabbits' fur, as described in the account of the hat manufacture, is an article of considerable trade. It is obtained chiefly from Europe, and is mostly consumed by the hatters, for whose use nothing but the fur itself in fleeces is imported. The whole skins are used to some extent by the furriers for cutting. The present character of the trade, and value of skins, are seen in the following statement from the circular of one of the oldest and most extensive houses in this business—that of Messrs. C. G. Gunther & Sons, of Maiden Lane, New York. To their experience we are indebted for many of the particulars that follow:—

Silver fox, according to size and color	From	$10 00	to	$30 00
Otter, northern and eastern, and north-western	do.	3 50	to	5 00
" Pennsylvania, New Jersey, Ohio, and western	do.	3 00	to	4 00
" Kentucky, Maryland, Virginia, and vicinity	do.	2 00	to	3 50
" North and South Carolina, and Georgia	do	1 50	to	3 00
Fisher, northern and eastern, according to size and color		2 50	to	6 00
" Penn., Ohio, and southern " " "		2 00	to	3 50
Bear, northern " " "		5 00	to	8 00
" southern " " "		2 00	to	3 00
Martens " " "		1 50	to	1 65
Wolf skins		50	to	1 00
Cross fox, northern and eastern, according to size and color		3 00	to	6 00
" Pennsylvania, New Jersey, and Ohio, do		2 50	to	5 00
Red fox, northern and eastern, do		1 25	to	1 50
" south Penn., New Jersey, and Ohio, do		1 00	to	1 75
" southern and western, do		50	to	75
Gray fox, northern and eastern, cased		40	to	50
" southern and western		30	to	40
Beaver, northern, parchment, per skin		1 00	to	1 50
" southern, and ordinary, per skin		50	to	1 00
House cat, ordinary		8	to	10
" black furred		15	to	20
Mink, New York and eastern, according to size and color		1 50	to	2 25
" New Jer., Penn., Ohio, Mich., Ind., Ill., Wis., and Iowa, do		1 25	to	1 75
" Maryland, Virginia, Kentucky, Mo., Iowa, and south, do		1 00	to	1 25
" North Carolina and Tennessee, do		1 00	to	1 25
" South Carolina, Georgia, Florida, and Alabama, do		50	to	1 00
Wild cat, northern and eastern states, cased		35	to	50
" southern and western		20	to	40
Raccoon, Mich., north. Ind., Indian handled, ac'd'g to size and color		60	to	1 00
" northern Ohio, Illinois, Wisconsin, and Minnesota, do		50	to	60
" New York and eastern states, and north Penn., do		40	to	50
" New Jersey, southern Penn., Ohio, Ind., and Ill., do		30	to	40
" Maryland, Virginia, and Kentucky, do		25	to	30
" North Carolina and Tennessee, do		20	to	25
" South Carolina, Georgia, Florida, and Alabama, do		10	to	20
Muskrat, spring		14	to	16
" fall and winter		7	to	8
" southern, average		5	to	6
Opossum, northern, cased		6	to	8
" southern		5	to	6
Rabbit, cased		1	to	2
Skunk, prime, black, cased		10	to	12
" white and black		3	to	5
" out seasoned and very white		0	to	0

Although the supplies of furs are diminishing, the trade in fancy furs, such particularly as are used for ladies' wear, is increasing in importance; and in the city of New York the wholesale and retail trade for the year 1856 was estimated to amount to about $1,375,000. The sales of a single house amounted in 1858 to about $800,000, and consisted altogether of fancy furs, such as sleigh-robes, caps, coats, gloves, and all articles worn by men and women. The same house exported, in addition to this, $350,000 worth of shipping furs, consisting of otter, beaver, muskrat, fisher, bear, silver fox, wolf, cross, gray, and red fox, raccoon, opossum, rabbit, and skunk. A decided change in the requirements for furs for ladies' wear has taken place within a few years. Instead of the cheaper sorts which formerly supplied the market, the more costly kinds are now largely in demand. Russian sable, which, since the opening of the Amoor river, is furnished in larger quantities and at lower rates, is much worn, and so are opera cloaks of the white ermine, tipped with black tabs, from the tail of the animal. A full set of the best Russian sable, consisting of a fichu Russe, muff, and cuffs, has been sold for $1,800. The fichu Russe is a large cape, falling below the waist, and from twenty-eight to thirty-three inches in length. Around the neck, it is finished with a collar four inches deep, and slightly pointed at the back. The usual prices for a set of this fur are from $700 to $1,500. Made of Hudson's Bay sable, the set is worth from $200 to $800. Some specimens of this fur are nearly equal in beauty, and quite so in

quality, to the lower grades of Russian sable. The mink is the most popular fur for the same use, owing to its moderate price, combined with good qualities, and a set of the finest is worth from $100 to $200. This and the sables are often ingeniously imitated by dyeing some of the cheaper sorts, as rabbit's fur, so that even experienced persons are sometimes deceived. The stone marten has been a fashionable fur, but though very handsome, it is giving place to those sorts of darker shades. It is distinguished by a white underground, and over this is the exterior shading of a light brown stone color. A fine set of this has usually sold for from $125 to $150. Fitch makes a good serviceable fur, but was never very fashionable. It is of yellowish hue, mellowed down in the best varieties by a long, thick overgrowth of dark brown. Sets of the darker shades are worth from $50 to $75, and others considerably less. Muskrat furs are sold under various names, as river mink, marsh marten, American sable, and French mink, and are worth in a full set from $28 to $35. The French cony, called also French sable, is a French rabbit, colored brown, with black stripes through the middle of the skin, in imitation of mink and sable. A set of this fur, of best quality, costs from $20 to $25. Two sorts of squirrel furs are made up, and mostly for children's wear alone. One is entirely gray, and the other mixed gray and white, and their value is from $25 to $40 the set. The white fur worn by children is of the miniver and white cony. Sets of furs are complete with a victorine or small cape in the place of the large one, and are, of course, furnished at considerably less cost. Fur overcoats for gentlemen are rarely seen in this country. A few have been introduced from Russia of great elegance, both sides being of rich fur, so that either might be worn outside. Ladies in the cities often preserve their expensive furs during the summer, by depositing them with the fur dealers, who take the same care of them as of their own stock.

The mechanical processes to which furs are subjected are few and simple. The skins when stripped from the animals are merely dried in the sun, in order to protect them against putrefying. Those of small size are often first steeped in a solution of alum for more efficient protection, but the operation is objectionable, as the alum weakens the pelt. They are made up into bales, and are called peltry. When stored, it is essential to keep them perfectly dry; and to guard against injury from moths, camphor and tobacco are strewed among them; and they must be examined every few weeks, and each skin be beaten with a stick in order to cause the worms of the moth to fall upon the floor, when they are crushed by treading upon them.

The first process of the furrier is to soften the pelt. This is done, with the finer kinds, by placing them in a tub with a quantity of butter and trampling them. After stripping off the loose pieces of skin, they are again trampled in sawdust (that of mahogany being preferred), the effect of which is to remove the grease, and the cleaning process is completed by occasionally beating with a stick and combing the fur. The skins are now ready for the cutter, who from a large number cuts out pieces of various shapes, which are then sewed together to make up the various articles of fur dresses. Each cape, muff, etc., is thus made up of pieces from different skins, and the numerous seams are concealed on the outside by the fur itself, and on the inside by the lining.

Furs that are to be used for felting require first the separation of the long hairs. This is effected after the skins have been split, scraped, and pressed, by either clipping them down to the length of the short hairs, or pulling them out one by one as each is seized between a knife-blade and the thumb. When carefully trimmed and pressed, the skin is well moistened with water, and being held upon a board of willow-wood, the fur is cut off close to the pelt by means of a sharp, rough-edged knife. The whole clipping is kept in one fleece by means of a piece of tin held in the left hand, and up which the fur is slipped as it is cut. The rabbits' fur imported for the hatters is received in these light, loosely cohering fleeces, each being the fur of one animal. The skins of the beaver and nutria require much more thorough cleaning to remove the fat from the pelt and the grease from the fur, as by repeated scrubbing with soap and hot water. The thick, closely matted fur of the former has been successfully cut by machine knives, an operation that has always failed when applied to the more uneven and thinner kinds of fur. Some chemical preparations have been used to separate the fur from the pelt, but they are generally found to be objectionable, as they destroy in part the felting property.

HATS.

CHAPTER I.

EARLY HISTORY—MANUFACTURE—IMPROVEMENTS.

From an early period in the history of manufactures in the United States, the production of hats appears to have been prosecuted with considerable success. As far back as the year 1732, the business was so successfully carried on in New England and New York as to lead to complaints among the hatters of London, and representations of the injurious effects upon the trade were in consequence made by the London Board of Trade to the House of Commons. Being the most conspicuous article of dress, the hat naturally was an object of particular solicitude, and much more latitude was allowed in giving to it peculiar and fanciful forms than at the present time. And if our fathers failed to produce fine specimens of manufacturing skill, we must admit that, in adopting the graceful forms of the high Spanish hat, with its rounded brim, and ornaments of plumes, or loops and tassels, they certainly excelled us in their appreciation and selection of pleasing shapes, instead of such stiff and awkward forms as those of the fashionable hat of the present day. There was, however, with them, quite as great a variety of hats as with us, both in material and in figure. The common hats were of rough felt, usually of wool, or of wool and fur—sometimes of fur alone—and the practice was early introduced of covering the wool body with a plating of fine fur, felted by hand into the outside of the coarser material. The body was stiffened or not with glue, and sometimes water-proof stiffened with gum shellac. The round crowns of the early part of the century had given place, in the better kinds of hats, to flat tops, and the broad brims of some were turned up and looped, first on one side, then on another, and at last on the third, till it became the regular three-cocked hat. This, from being a fashionable hat, finally came to be appropriated to military officers, by whom it is still worn as a badge of rank. The Quakers alone adhered to the old broad brims, making it, it is said, a point of faith not to wear a button or a loop, and wore their hats "spread over their heads like a pent-house, darkening their outward man to signify they have the inward light." In the other extreme there were fashionable hats, like ladies' bonnets of the present time, too small to serve as a covering for the head; such a hat was conveniently carried under the arm, and in fashionable calls furnished a pleasant diversion to its owner, who twirled it upon the head of his cane.

Many of the soft hats of our ancestors were, no doubt, very fair articles of hand workmanship. They possessed abundance of material, and used the choice fur of the beaver more lavishly than hatters have of late been able to afford. Their mode of felting was the same as that now practised where machinery is not introduced, and their methods of shaping hats over blocks, or "sizing," were probably as skilfully conducted as at the present time. But in the production of the stiff pasteboard hats, covered with a sheet of fur or other material, the processes in use were comparatively rude, and have so continued down to within a few years past. Within our own recollection, the hatter in almost every village made the hats he sold, felting his own materials and forming the bodies over his blocks, and covering with them the stiff and clumsy cylinders of pasteboard, shaped, as near as might be, to the prevailing forms of the day. The fur of the musquash and beaver were used, often plated upon a body of lamb's wool; and the choicest beaver hats were plated with the finest fur of the animal, taken from the belly and cheeks. This, too, came to be used upon bodies of rabbits' fur, of which the so-called beaver hats at last were chiefly made; and as beaver became scarce,

nutria, from a South American animal of this name, was very generally substituted for it. The hatter was provided with dyeing kettles, in which the complex materials of his hat bodies were brought to a uniform black shade; and there was a variety of apparatus for steaming, shaping, and finishing, all of which involved laborious hand-working, and more or less mechanical skill, to produce the small number of hats required by the men and boys of the village.

Within a few years a complete revolution has been effected in this business. Machinery has been almost wholly substituted for hand labor in preparing the materials of hats, and this is now done upon an immense scale in a few of the large cities, whence the hat bodies, or the finished hats, are sent for the supply of the country. The effect of this has been to furnish hats of uniformly better quality than were made by hand, at greatly reduced cost, and to carry the manufacture to such perfection that the American hat is now distinguished as the lightest and best produced in any country. In England, the American is often recognized by the excellence of his hat. For this we are in part indebted to the greater dryness of our climate, the moisture of England rendering it necessary to give more body and stiffening to the hats exposed to its influence. This is not so much the case in France, and hats there approach more nearly the quality of our own.

In New York city the business in the common felted hats of wool and of fur, which make no pretensions as works of mechanical skill, is carried on upon an immense scale in numerous establishments; and it is stated that the commission houses and agencies engaged in this trade, which are concentrated chiefly in the lower part of Broadway, sell over 5,000,000 hats annually.

The business in stiff hats is quite a distinct branch, and their manufacture is extended through several different establishments. The making of the bodies is almost monopolized by the firm of Messrs. Henry A. Burr & Co., of New York city, and by their patented machinery, supplied to agents in a few other cities. They receive from the hatters, who buy of the importers, lots of rabbits' fur—the chief supplies of which come from towns near the German Ocean, as Frankfort-on-the-Main, Brussels, etc. Some of poorer quality is also obtained from Virginia and North Carolina. The fur of each lot is mixed together, and to every 4 or 5 ounces (the usual quantity for a felt hat) ¼ to ½ an ounce of the finest carded cotton is added; and at the same rate for the lighter fashionable hats, the weight of which is about 3 ozs. Picking machines, revolving with great velocity, and creating, in a capacious box, a powerful current of air, cause the fur to be well mixed, the operation being repeated to make it thoroughly effectual. The long hairs and bits of pelt are then separated by what is called the blowing machine. This consists of pickers, which revolve several thousand times in a minute, and strike out the coarse hairs and heavy particles, which fall upon a screen, while the light hairs are blown upward and carried forward to another compartment, where the same process is repeated. The screens are kept in agitation, and the coarse particles are finally shaken off at the feet of the man who feeds the machine, and by him they are again passed through to save the fur that adheres to them. The dust escapes through the perforated copper covering of the machine, and the clean fur is delivered at the extreme end in a fine flocculent condition, readily worked into a mat by felting, as is shown by rolling a little of it between the fingers. In the large factory of the Messrs. Burr & Co., about 30 of these machines are kept in operation, and the quantity of fur prepared by them is enough for about 10,000 hats daily. This number of hat bodies has been produced at this factory for several months together. Two steam engines are employed by turns, one of which is of 400, and the other of 200 horse power.

The fur used to be felted altogether by the hand process: but various improved methods have been devised for lessening the labor; and the best of these are of American origin. By the process invented by Mr. Thomas Blanchard, of Boston, the fur was made to collect upon a fine wire gauze, and there take the form of a matted ribbon, by exhausting the air beneath so as to create a strong current of air from the receptacle in which the particles of fur were kept floating in the air. This ribbon being wound around a double conical block, of the size of two hat bodies, was then joined along the overlapping edges by rubbing. The method of Messrs. Burr & Co. is an improvement upon this, perfected by Mr. Henry A. Wells and Mr. Burr. A cone of sheet copper, considerably larger than a hat

body, punched full of small round holes, is set upright, and made to revolve slowly upon a vertical spindle. An exhausting fan under it rotates about 4,000 times in a minute, causing a strong current of air to draw through the holes from the outside. Against the cone is the mouth of a sort of trunk, or long box, in the opposite end of which the fur is fed in quantities just sufficient, each time, for one hat body. The fur is taken up from the feeding apron by a cylindrical brush, and thrown forward by the rapid revolutions of this, which also create a current of air that blows the fur toward the mouth of the box. From thence it is seized by the exhausting current, and drawn down upon the cone, covering this completely, while it is turning round sixteen times. The workman standing by picks off any coarse particles that fall in with the rest, and as soon as the deposit is completed, he lays a wet cloth over the cone, and places over all a loosely fitting metallic cover. He then lifts off the whole, and immerses it in a tank of hot water, replacing a new cone immediately, to receive the next hat body. The effect of the hot water is to make the particles of fur cohere more closely together. When taken out of the water the mat is placed in a piece of blanket, and worked by the hand upon a table. It is then squeezed, to press out the water, and folded, to be pressed with others, and made up with them into bundles for the hatters. The shape of these bodies is that of a wide, open-mouthed bag, of a size much larger than the hat. They are very soft, and tolerably strong, and are afterward reduced to the required dimensions and shape by the process called "sizing," which is done by the makers of felt hats for themselves, and for most of the larger manufacturers of silk hats by intermediate establishments specially devoted to this object.

The immense advantage gained by these improvements, is seen in the enormous production of the factory of Messrs. Burr & Co., which, in 1856, amounted to about 3,000,000 hat bodies, besides about an equal number made by their machines in other cities. These were, moreover, of uniform quality, according to the kind of fur used, and every one free from imperfection. By the old method, it was the labor of a skilful man to form four or five bodies in a day; and these were generally inferior to the machine-made bodies. Their cost was estimated at 56 cents each. The new machines, called "formers," employ, each one, two men and a boy to tend them, and another man is occupied in rolling and putting up the bodies. Their production is 400 a day, and the cost of the labor employed is rated at from six to ten cents for each hat.

The "sizing" of the bodies, as performed by the manufacturers of felt hats, and those who prepare them for the makers of silk hats, consists chiefly in rubbing a pile of the bodies after they have been dipped in hot water, and rolled in a blanket upon a sloping plank table, that forms the margin of a large, central tank. This is called the hat-maker's battery, and is large enough for eight to twelve men to work around it. By rubbing the bodies they soon felt together more closely, and are reduced to the proper sizes for hats. Those intended for silk hats are called shells; and in this condition are sent to the factories where these hats are made up.

Silk hats, which are the latest and most perfect improvement in this art, are made by covering the stiffened fur bodies or shells with black plush specially prepared for this use, and supplied to the trade from France, the best dyed coming from the manufactory of Martin, of Paris. This business is carried on in several large establishments in New York, Philadelphia, and other cities; and from these the fashionable hatters are supplied with hats made to order and marked with their names. The country trade is also supplied from the same sources, but with hats rather heavier and stronger than those made for city wear. The latter weigh when finished only about three ounces, and are not usually expected to continue in wear more than a few months; not because of their becoming shabby in this time, but because slight changes in the form are continually introduced, which wearers must adopt to keep in the fashion; and in the city there is more disposition and means for always wearing the best.

The manufacture involves a variety of processes, each of which, after the most economical system of division of labor, is conducted by workmen specially devoted to this alone. By one set of hands the soft shells are first subjected to the operation of waterproof stiffening. They are dipped one at a time in a weak solution of shell-lac, then slipped over a block, and partially brought into shape by rubbing with the hands. The

brim and tip (or edges of the top) are then brushed over with a thicker coating of the gum to give additional stiffness to these parts. When dry, a hot iron is applied, which has the effect on cooling of giving greater hardness and solidity to the material. The next application is a coating of fine glue or gelatine, the object of which is to prevent the varnish of seed-lac, which is next laid on, from striking in. The hats are after this taken to the finishing-room, and here are first shaped and trimmed, to the exact pattern sent with the orders from the retail hatters. In this operation brass gauges of a variety of forms are made use of, by which the exact dimensions and shapes required are secured without the slightest deviation. The silk plush has been in the meantime already prepared by sewing a circular piece for covering the top, with great nicety to the piece which surrounds the body, the two edges of which meet in a line up and down the side of the hat. The brim is covered by a separate piece above and below, and the edges of these pieces are afterward concealed under the binding and the band. A hot iron is applied, in order to smooth the plush and cause it to adhere to the varnish, which is softened by the heat of the iron. After being lined and trimmed, the hat is finally smoothed and shaped with a hot iron, and the precise curve required is given to the brim, the finishing of which demands the skill of a practical workman.

VIEW OF CHICKERING & SONS' PIANO-FORTE MANUFACTORY, TREMONT STREET, BOSTON.

INDIVIDUAL INDUSTRIES.

The great progress of this country, as evinced in the developments of the preceding articles, is manifest to the civilized world, in the position which the country occupies among the nations of the earth. If we have followed the progress of each leading branch, from small beginnings up to the magnificent results that they now display, it has been to show that these results, great as they are, are but the preliminary to that career which the future promises. It is to be borne in mind that the capital of the country had to be created, and that the large enterprises could be carried out only by an accumulation of capital that grew as it was applied. The manufactories, the mines, the finances, the railroads of the country, were nearly all carried on by associated capital acting through corporate bodies. Underlying those vast undertakings, however, are the broad fields of individual industry, where every man, depending only on his own skill and perseverance, not only, as it were, created an industry, but devised the means of making it useful. The inventive genius of the people has been systematically applied to the improvement of qualities of goods made, at the same time that the cost of manufacture has been cheapened. The field of individual industries may be explored with quite as much interest and admiration as those which have been opened by the application of incorporated capital. The wonderful results that have been obtained have been accompanied by the fortunes of the enterprising men that have produced them. It is the case sometimes with corporate capital that the greatest enterprises are carried out successfully for the public interests while the capital invested in them has been sunk. In the case of individual operation, a combination of mechanical inventions, of industry classified, of raw materials judiciously assorted, and of directing skill, produces articles that, before unknown or unappreciated by the public, have become necessities, and the demand rewards the genius and judgment of the manufacturer with a fortune. In almost all cases, but little money capital was possessed at the commencement, but there was a better capital than mere money in the self-reliant genius of the indomitable American. These individuals have remodelled old manufacturing processes with improvements, and created others, giving employment to thousands of workers, and creating interchangeable values for the great natural products of the country; in other words, finding a market for labor which would otherwise not have been available. In the present article we will explore a number of the leading industries of this nature.

BUILDINGS AND BUILDING MATERIAL.

Among the marvellous evidences of the advancing wealth and luxury of the American people, the multiplication and improvement of dwellings are very conspicuous. The official figures in relation to the numbers and values of dwellings in the country are indeed not very abundant or very precise. There are materials, however, which, put together, give a pretty accurate estimate of the enormous investments in dwellings.

In 1798 the number of dwellings and their value in all the states, was given in the tax-list laid before Congress. The values given in the official tax list at the end of the last century not only apply to a class of dwellings far less costly than the average of those now in vogue, but it was at a time when money or capital was of a higher value relatively. The number and value of the houses then reported may be compared with the number of dwellings reported in the United States Census of 1850, as follows:—

NUMBER AND VALUE OF DWELLINGS IN THE UNITED STATES.

	1798.		1850.	
	No. dwellings.	Value.	No. dwellings.	Value.
Maine	part of Massachusetts.		95,802	$72,109,000
New Hampshire	11,142	$4,146,938 90	57,339	43,004,250
Vermont	5,437	1,558,389 36	56,421	42,315,750
Massachusetts	48,984	24,546,826 46	152,835	114,626,250
Rhode Island	7,037	2,984,002 87	22,379	16,784,250
Connecticut	23,465	8,149,479 28	64,013	48,009,750
New York	33,416	25,495,631 39	473,936	354,452,000
New Jersey	19,624	9,149,918 84	81,064	60,798,000
Pennsylvania	51,772	29,321,048 33	386,216	289,662,000
Delaware	5,094	2,180,165 83	15,290	11,464,500
Maryland	16,933	10,738,286 63	81,708	61,281,000
District of Columbia	..	..	7,917	5,937,750
Virginia	27,693	11,248,267 67	165,815	124,361,270
North Carolina	11,760	2,932,893 09	104,996	78,747,000
South Carolina	6,427	5,008,292 93	52,642	39,481,500
Georgia	3,446	1,797,631 25	91,206	63,404,500
Florida	..	..	9,022	6,766,500
Alabama	..	..	73,070	54,807,500
Mississippi	..	..	51,681	38,760,750
Louisiana	..	..	49,101	36,825,750
Texas	..	..	27,988	20,991,000
Arkansas	..	..	28,252	21,189,000
Tennessee	1,030	286,446 83	129,419	97,065,750
Kentucky	3,339	1,139,765 13	130,769	98,076,250
Missouri	..	..	96,849	72,344,850
Illinois	..	..	146,544	109,908,000
Indiana	..	..	170,178	127,629,500
Ohio	..	..	336,098	252,073,530
Michigan	..	..	71,616	53,712,000
Wisconsin	..	..	56,316	42,237,000
Iowa	..	..	32,962	29,971,500
California	..	..	23,742	17,806,500
Minnesota Territory	..	..	1,002	751,500
New Mexico Territory	..	..	13,453	10,089,750
Oregon Territory	..	..	2,374	1,780,500
Utah Territory	..	..	2,322	1,741,500
Total	276,559	$140,683,984 77	3,362,337	$2,520,967,400
Number of churches	..	..	36,221	87,049,459

The national census of 1850 did not give the value of the dwellings, but the state census of New York for 1855 gave not only the dwellings but their value and material of construction. By that census it appears there were in New York 522,325 dwellings, worth $664,899,967, or an average of $1,267 each. The average for stone houses was $6,526. These are mostly the better class of houses belonging to the wealthy inhabitants of towns. The whole number of these is 7,536, of which 1,617 are in New York city, and worth $32,267,340, or an average of $20,000 each. In the remaining portion of the state the stone houses are 5,919 in number and $16,917,479 in value, or an average of nearly $3,000 each. The New York stone houses and hotels are exceptions, being the most luxurious display of the wealthy few. The number of brick houses is 57,450, average, $5,433; and of frame houses, 397,638, average value $748.

If, then, we assume $750 as the average value of the dwellings in the whole Union, the result for 1850 will be an aggregate of $2,521,752,750 invested in dwelling-houses, being an increase of $2,381,068,765 in 52 years, or nearly $50,000,000 per annum for 52 successive years, in addition to the $87,049,459 invested in churches. The sums absorbed by other public buildings are not specified. The building which has been done in the last ten years by far exceeds that ratio. Thus the New York State census gives the number of dwellings in 1855 at 522,325 against 473,936 in 1850, an increase of 48,389, or more than 10 per cent. in five years. Comparing dwellings to the population, the results are as follow :—

UNITED STATES.

	No.	Free population.	Persons to each house.
1798	276,659	4,412,884	19.00
1850	3,362,337	20,059,399	5.94
1860	4,333,730	28,000,000	6.00

NEW YORK STATE.

	No.	Population.	Persons per house.
1798	33,416	586,754	19.00
1850	473,936	3,097,394	6.53
1855	522,325	3,466,212	6.64

The number of persons to a dwelling was greater in New York in 1850 than the average of the Union, and that number slightly increased; in the next five years that increase was again narrowed to the city of New York, where the crowd of foreign arrivals and large hotels and boarding-houses raised the number of persons to 15 for each house.

The population of Philadelphia and the number of dwellings are as follow :—

	Population.	Dwellings.	Persons per dwelling.
1850	408,762	61,278	6.10
1860	568,034	89,978	6.05

In Philadelphia the increase of dwellings per cent. appears to be less than the progress of the population.

The general result in the Union is a house for every free white family, and these families average 5½ persons each. From these figures it is apparent that the number of houses in the Union progresses in the ratio of its free inhabitants. Thus, in 1850, the number of houses was to the population of the whole Union as 1 to 5.94; assuming that for 1860 there are 6 persons to each house, there must now be 4,333,333 houses, an increase of 970,996 houses in 10 years, at a value of, in round numbers, $800,000,000. In the same proportion, there must be, in 1870, 5,600,000 houses, which, at the value of 1855, would be $4,200,000,000. In other words, during the present decade, 1,300,000 houses must be built, and it is probable, from the advancing luxury of the age, they will cost more than those of 15 years before, and one thousand three hundred millions may be required for the expenditure. This is a necessity of increasing numbers, and provides nothing for re-construction, or churches, or public buildings. This item of house-building in an increasing country stands out in contrast to the demand in the same line, in old and stationary countries of Europe. Some of those old cities were built 500 to 1000 years ago, of solid masonry, and very few houses have since been added. There is no active and continued demand for labor and capital to provide new dwellings to accommodate swelling numbers. On the other hand, the empty dwellings frequently give melancholy signs of a departing population.

In the United States, not only does this vast annual demand for 130,000 new houses exist, but every year brings improvements in the style of construction and the luxuriousness of accommodation. The simple frame buildings that generally spring up on the outskirts of cities, are, before they are yet old, required to give place to brick buildings, since the spreading population carries the municipal laws which forbid wooden structures over larger limits. The brick buildings that supplant the frame must also be more substantial, since the same fire laws also prescribe the thickness and stability of the walls. Wealth follows with its more pretentious style, and brown stone or marble palaces rear their stately fronts on what was lately an open lot. With the improved style of houses there is a constant ambition to occupy a "modern house," or one with the "modern improvements," which may be enumerated as, warming apparatus, whether by hot-air, water, steam, or gas; the water-pipes in all the rooms, connecting with the cooking-range for facility of heating; water-closets and bath-rooms connected with street sewers to carry off the waste water; bells, speaking-tubes, telegraphs, ventilation, burning-gas, dumb-waiters to communicate with different floors, and all the luxury of arrangement and embellishment which makes a modern private dwelling so far in advance even of the fairy palaces of the Arabian Nights' Entertainments. There is a natural desire on the part of all to obtain, as circumstances will permit, a better house, and if these are not built in the substantial manner which in Europe defies the ravages of time, they are in the fashion and luxury of the day, and may be altered or re-constructed as fortune changes. The railroads that give access to the neighborhood, in such a manner that a business man may take his breakfast at 7½ o'clock, ride 40 miles, and be at his office before bank opens, has, so to speak, carried city houses into a broad circle of country, and "villas" rise rapidly from the soil, also provided with all city improvements. Thousands of miles are within this influence. In sections which, a quarter of a century since, were shadowed only by the native forests, in which the scream of the panther and the gleam of his eyes startled the benighted traveller, streets of marble fronts now emit the glare of gas and the latest creations of the opera. In all directions the gaze of the traveller falls upon

new creations, where lumber, brick, stone, and lime are combining into a dwelling or a factory, a school-house or a church.

The increase of houses being proportioned to the increase in the numbers of the people, their value has risen in the ratio of their growing wealth. It is remarkable that the country, in all its sections, abounds with the best materials for all description of dwellings, and yet these materials were very slowly discovered. For long years the bricks with which the best houses of New York were built, were brought from Amsterdam in those stately old droguers which, on their arrival in the bay of New Amsterdam, were regularly dismantled and laid up over the winter, setting out on their homeward voyage with the early spring. The bricks were probably used as ballast, but even then the cost of a house so built was something important. The early houses of the settlers were log huts, but subsequently frame houses were raised by the more ambitious, and, as wealth increased, those "shingle palaces" that became famous in the stories of New England manners, began to dot the country. In the cities, frame houses were the rule down to a comparatively late date, when the fire laws forbade the erection of wooden tenements within certain districts. The abundance of timber not only for building purposes, but for fuel, was a great advantage to the country. But as the population increased, the inroads upon it became very heavy, and the forests were rapidly thinned out. The annual consumption exceeded the growth, according to the estimates of the most experienced lumbermen, by about 30 per cent., and this notwithstanding that coal came to supply the drafts made for fuel, and the substitution of bricks for city houses. The sources of lumber for building purposes have become more diversified as the demand has increased. The State of Maine was for a long time the head-quarters of the trade for pine, spruce, and hemlock lumber; but hard pine comes from North Carolina, Georgia, Florida, and Alabama; Ohio and Michigan supply black walnut, cherry, ash, white oak. The exports from the country are about $2,500,000 per annum, and ship-building makes large drafts upon it. The lumber trade at various leading points, where the lumber resources of the back country are most readily concentrated for market, may be given as follows:—

	Feet.	Lath. M.	Shingles.
Detroit....	76,537,000	13,491,000	36,647,000
Savannah .	23,365,656	..	..
Charleston.	15,312,128	..	..
Albany....	291,771,762	..	48,756,000
Bangor....	176,187,016	..	..
Cincinnati.	32,000,000	..	..
Chicago...	300,982,207	49,102,000	165,927,000
Milwaukee	65,000,000	..	..
Oswego ..	144,654,572	1,643,500	7,653,250
Cleveland .	28,950,000	..	..
Baltimore.	100,000,000	..	28,000,000
Boston	131,000,000	20,000,000	10,000,000
Buffalo....	68,558,151	2,026,000	1,768,300
Philad'phia	162,879,722	..	21,220,937
Total...	1,661,568,214	86,262,500	320,072,487
Value..	$31,931,364	$138,797	$1,280,289

The Bangor lumber is derived from the forests of that region, and it composes a part of that sent to Boston, Philadelphia, etc. The Savannah and Charleston trade is that shipped from those ports, mostly North. The Albany lumber is derived from the canal deliveries and the northern section. The Philadelphia lumber comes mostly from the canals and rivers; about one-third comes through the Chesapeake and Delaware Canal, as much more down the Delaware river from southern New York: about one million feet only comes from Maine. The Baltimore supplies are mostly from the Susquehanna river, being rafted down from Pennsylvania and New York. From 150 to 200 millions of feet go down the Alleghany river every year. Chicago is by far the largest lumber market, and the supplies are derived from the Michigan Lake shore, the largest quantity from the Green Bay district. The supplies are sent through the state by canal and the various railroads that radiate through the prairie country, where wood of natural growth is scarce, and which scarcity was one of the objections to settling until railroads became the means of furnishing the supplies. The largest quantity goes by the canal, and the next largest by the Illinois Central railroad.

With the vast supply of lumber and timber to meet the additional demand for building purposes, it followed that improvements in the mode of preparing it would not fail to make their appearance. It is obvious that inventions are more likely to take place when the quantities handled are very large, than where but little is done from year to year. Thus if a few houses are built occasionally, the want of great facilities will not be so marked as when twenty hundred mil-

lion feet of lumber is to be worked up every year for building purposes, mostly in the construction of dwellings. The carpenter, in the building of houses, receives the beams, scantlings, planks, and boards, and out of them he makes bond-timbers, wall-plates, roofs, floors, etc., and with the completion of strong skeletons his labors end. The joiner, plasterer, and plumber succeed him. In the formation of his frame, the first is employed in notching, cogging, tenoning, pinning, and wedging. For many of these operations very effective machines have been introduced, especially for mortising, floor planing and grooving, etc. Some of the inventions, like the planing machines introduced in 1837, are of great value and influence. Circular saws, scroll saws, and a crowd of inventions bearing upon every part of the work, have wonderfully facilitated the work of the carpenter and joiner. The blinds, sashes, doors, window-frames, have become separate trades, each of which supplies its portion much cheaper and more perfect than formerly. When the demand is large, these are supplied with great precision. House-building thus becomes a trade. In the large cities a speculative builder becomes possessed of a number of open lots. On them money is borrowed to build a block of houses, 4 to 12 in number. With the money thus borrowed the work is hurried on until the roof is on, when the whole is regularly mortgaged to secure first loans and to obtain enough to complete the buildings. In the mean time they are offered for sale, and generally sold by the time they are done.

In order to facilitate the sales much credit is granted, a little money above the sum of the mortgages being all that is required. The mortgages remain at 7 per cent., which, with the taxes, etc., make the rent rather high to the owner. It not unfrequently happens in some neighborhoods that houses may be rented for an annual sum far less than the interest on the sum demanded for the house. Nevertheless, the person who has paid a little money, and lives under a mortgage larger than the whole house would cost if built with ready money, has the pride of a house-owner.

Sometimes the builders, carpenters, plumbers, painters, all furnish their parts of the work, and grates, furnaces, etc., also put in either on shares or secured by "mechanics' liens,"—all these to be paid out of the purchase money. It not unfrequently happens, however, that the expenses of raising money to go on carry the cost of the houses too high to get the money back, and foreclosure finally settles the account. Houses are also made for exportation, as well of iron as of wood, as in the case of the early times of San Francisco, which received many of its dwellings from New York. The settler on the new lands of the West is now not always required to plunge into the wilderness and rear his first shelter from logs, but may have his house sent from Chicago or other cities by railroad, and put up to await his coming. In all this lumber figures largely. With the settlement of the western country, the demand for lumber is urgent, and new supplies are opened up. The most extensive of them is round the Falls of St. Anthony, where about 100,000,000 feet of new logs come down in the spring from the waters above. These logs are manufactured into lumber at the extensive mills round St. Anthony. One of these mills will cut 92,000 feet of lumber, 50,000 lath, and 20,000 shingles in a day of 12 hours. The mill employs 150 men. There are cut probably 200,000 feet per day for the supply of the lower country with lumber. At the extreme South lumber is also supplied. Some 20,000,000 feet are shipped from Pensacola to the Atlantic and Gulf cities, in addition to the large quantities used in the place. The Dismal Swamp Canal at Norfolk delivers 3,000,000 feet of plank per annum, and 50,000,000 shingles, 400,000 feet of timber and 8,000,000 staves.

The material for dwelling-houses is thus liberally supplied at the leading points, to and from which means of communication have been so extensively provided. The majority of country houses are of lumber, or frame houses. In the cities the majority are brick, and, as we have said, many New York houses are still standing built from the small yellow brick brought from Holland. Brick clay is found in most of the states, but not of the same quality. The best brick are Philadelphia and Baltimore, but Chicago is famous for its straw-colored bricks. This color results from the absence of peroxide of iron in the clay. Some Milwaukee bricks were brought to New York city for the construction of Trinity Building, head of Wall street, and they assimilate in color to the old Holland brick, also "far fetched and dear bought." It is curious, however, that the

brick of the far West should mingle with that of Europe in the composition of the city of New York.

In the manufacture of the brick the clay is obtained as pure as possible; but it must be exposed for some time to the air and weather, which soon disintegrates its particles, and fits it to be kneaded into a mass. The clay is then soaked in a tank. The kneading was formerly done by animals or the naked feet of men, which machinery has superseded. The clay is now first ground in the pug-mill, which is a tub in which revolve on a shaft blades that cut and knead the clay as it is fed in from above, and passes out at the bottom. It is then cut into pieces and stacked for use. The old hand mode of moulding was to throw the clay into the mould by force and then scrape off that which was superfluous. The labor of this process was reduced by causing the moulds to receive the clay from the mill in successive sets. It is obvious that the clay must be cleaned from all stones, sticks, etc., that would disfigure the brick. When the bricks are moulded they are dried. For this purpose a level yard is prepared, and bricks are brought in the moulds, which are removed, leaving the bricks to dry, a longer or shorter time, according to circumstances. If the bricks are not thoroughly dry they will crack in baking. For the purpose of baking, the bricks are piled one upon the other, to make the kiln or clamp. These contain from 500,000 to 1,000,000 bricks. A central double wall is built, lengthwise the lower portion, of baked bricks. On both sides longitudinal fire flues of green brick are built. Over them the mass of bricks is laid, with flues leading to the top, and in an open manner, with small scuttles through the heap as it is built up. The top and sides are built of baked bricks. Over all loam is laid to prevent the fire from burning too rapidly. The time required formerly on the Hudson river for burning the great clamps of 1,000,000 bricks was two weeks, and there were required 40 cords of wood for 100,000 bricks. About the year 1838 fine anthracite coal dust was introduced into the clay in the proportion of 75 bushels to 100,000 bricks, and thoroughly mixed in the kneading. The effect of this was to reduce the time to four days, and the wood to 16 cords for 100,000 bricks. Thus 16 cords of wood is rated at $80; 75 bushels of dust, $3; 4 days' attention, $6; total cost, $89, against $212. It follows that, as the heat is very unequal in a clamp, some bricks are underdone, while others are slightly fused on the surface, called "clinker brick."

It is obvious that in brick machinery the saving of labor is the great object, and to attain that a great number of machines have been invented. One of this class forces a lump of clay of the breadth and depth of a brick along a trough; and it is cut off the proper length by a wire. Other machines have been made to stamp the brick out of a lump of clay. Again, the clay is forced into moulds by a heavy roller. There are machines which pulverize the dry clay, and press this with great force into moulds, ready for burning. A patent for this, taken in Baltimore in 1847, and another in Boston, pulverizes, screens, moulds, and presses 2,500 bricks per hour. On this plan bricks are made on Staten Island. They present a smooth surface, but they are not so good as the Philadelphia and Baltimore. Bricks have been made partly hollow to diminish the weight. The size of bricks is $7\frac{3}{4}$ to $8\frac{1}{2}$ inches long, 4 to $4\frac{1}{2}$ wide, and $2\frac{1}{4}$ to $2\frac{1}{2}$ deep. In New York 5 courses of brick are allowed to the foot in height. In New England 5 courses make a foot, without the mortar. The weight of a brick is about 4 lbs., and 21 make a cubic foot of wall. The Philadelphia brick are the best in the country, and are made mostly by hand. The clay and sand give the brick a better color. The Baltimore brick bring a better price because the clay is purer, and therefore stronger, are better burned, and less liable to damage by transportation. The quantity made in Philadelphia is reckoned at 100,000,000 per annum.

The lime used in New York and on the Atlantic coast is mostly of Thomaston, Maine, where it is manufactured of limestone and oyster-shells. Its quality is much superior to that of the lime of other sources. The chief use of lime is for making mortar for cementing brick and stone work and plastering walls. The best qualities, made from pure stones or shells, slake rapidly, and are called fat. This kind more than doubles in bulk on being slaked, and falls into a soft, white paste. The inferior qualities slake slowly, and give out but little heat in the process. The value of lime with masons depends upon the quantity of sand it will bear in the manufacture of strong mortar. Thus the best Thomaston lime will take 8 bbls.

of sand for one of lime. It is stated that an excellent lime is made near New York city from white marble, and that it will take 9 bbls. of sand. The Thomaston lime is burned with anthracite coal. In New York it is used for plastering, at a price of $1 to $1.30 per bbl. of 2½ bushels. A cheap lime from Ulster county is sold at 70 cents for stone work. In the mortar each atom of sand is surrounded with lime, which adheres closely to it, and attaches it to adjoining portions, becoming hard by exposure to the air.

The building stone of Boston for the best houses has been derived from the immediate neighborhood, and is called Quincy granite. It is a handsome gray stone, hewn for dwellings, but sometimes used unhewn for public buildings. The stone is derived from Quincy, and the first railroad started in the country was for the service of these quarries, having been introduced shortly after their opening. The stone now so well known and extensively used, not only in Boston but in most of the Atlantic cities, as well as the West India Islands, was a discovery of the present century. It was formerly supposed that, where there is but little soil there is also no stone, and it is recorded that stone for the foundation of the dwelling of Governor Phillips was brought from Rhode Island. The State House was, through scarcity of stone, built with brick. Granite quarries are also now worked near New York and in Delaware Bay. These sources supply some of the stone for New York city, where a coarse marble, known as Sing Sing marble, is also used. The chief stone relied upon for the fashionable dwellings is, however, "brown stone," from the Portland quarries of Connecticut. It by no means follows, however, that a brown stone palace "on an avenue" is built of brown stone, any more than a brown painted house is built of "paint." The house is usually built of lumber and brick, and a thin coat of brown stone put on the front. The difference in cost between a plain front of stone and one of Philadelphia brick, with stone trimmings, will be from $700 to $1000. For the construction of large and fashionable stores, the Sing Sing marble is mostly used, but iron fronts have come latterly much into use. These are cast in ornamental styles, and put up piece by piece, each being riveted to the other, the whole front thus forming one piece, and then painted to resemble stone. Marble is the favorite material in Philadelphia, notwithstanding her superior brick. It is procured in abundance a few miles from that city.

Stone at the West is not so abundant, but discoveries of good building stone have been made. A yellow stone in the neighborhood of Cincinnati supplies a handsome material to that city. The canals of Ohio and Illinois carry considerable quantities, and marble has been found near Dubuque. There are valuable quarries in the neighborhood of Chicago. Iron is destined to figure largely in fronts for stores, as well as for the construction of fire-proof grain depots.

How long the once mighty forests of the country will supply the prodigious and growing demand for the use of dwellings, is a problem; but long since, the demands of shipwrights have so thinned the Atlantic forests, that it has become cheaper to build upon the lake harbors and western rivers. The scarcity of knees and bends for ship-building, led to the invention of the timber-bending machine, by which the straight oak timber was claimed to be bent in curves or at right angles for knees without decreasing its strength. The ports of the West, however, have of late been appealed to, and vessels built at Cleveland and other lake ports, at a small cost for lumber and labor, find their way to sea much cheaper than the same class built on the famous old ways of Maine, Massachusetts, or Baltimore. The white oak becomes less abundant, and live oak no greater in supply, while the pine and other woods used in the floors and trimmings, compete with the demand for dwellings. The number of vessels built in 1858 was 1225, of 242,286 tons. Of these nearly one fourth were built in the state of Maine, one eighth in Massachusetts, as much in New York, and ten per cent. in Philadelphia. If we compare the number and class of vessels built in the western states of Illinois, Ohio, Indiana, Missouri, Wisconsin, Michigan, in 1859, with 1829, we shall observe the progress in 30 years:—

	Ships.	Brigs.	Schooners.	Sloops and canal boats.	Steamers.	Total.	Tons.
			WEST.				
1829		1	12	4	25	42	9,032
1859	4	1	65	37	98	205	45,731
			ATLANTIC.				
1829	44	67	473	141	18	743	68,066
1859	118	44	366	365	128	1,021	196,555

The tonnage built at the West has increased fivefold, while that on the Atlantic has increased less than threefold. In 1860 an enormous stimulus was given to ship-building in all the western ports. Milwaukee did a large business, and the lake tonnage was greatly increased. The whole quantity of tonnage built since the accounts were kept has been 5,212,743 tons, or a value of $260,637,000. Of this amount 3,400,000 tons, or a value of $170,000,000, have been built in the last ten years. The annual value built is over $16,000,000, and the value of the lumber used $9,000,000, and there are about 13,000 men employed. The census of 1850 gives the statistics of house and ship building as follows:—

	No.	Capital.	Material.	Hands.	Cost of labor.	Value produced.
Carpenters	2,790	$3,289,308	$7,011,930	15,276	$5,559,320	$16,886,819
Ship-builders	892	5,182,309	7,286,401	12,623	5,922,576	16,595,683
Bricks	1,603	4,367,912	1,474,023	16,726	4,235,088	6,610,731
Lime and plastering	761	1,124,072	1,106,775	2,834	735,746	2,286,242
Lumber-yards	17,895	40,038,427	27,593,529	51,766	16,022,052	58,520,966
Masts and spars	39	124,130	89,719	154	63,216	189,482
Plumbers	124	646,225	1,297,119	1,037	377,944	2,343,607
Sashes and blinds	433	1,066,355	859,827	2,448	860,920	2,277,061
Shingles	520	823,940	406,932	2,127	425,328	985,957
Quarries	1,144	4,032,182	2,475,760	9,996	3,431,194	8,180,115
Timber-hewers	129	222,479	14,742	414	67,508	132,246

The New York census of 1855 gave the number of feet of lumber used per annum in house-building at 5,953,000; ship-building, 16,938,000 feet; boat-building, 7,673,000. The number of brick made in the state was 408,052,000, and 4,214,000 bushels of lime.

CARRIAGES AND COACHES.

The improvements in the means of transportation in the United States are very manifest in the number and quality of private carriages of all kinds that are now kept by almost all who live out of cities, and by very many of those who reside in them. With the multiplication of railroads, which were to supply the place of stage-coaches, it was supposed that the number of horses employed would be greatly diminished. The contrary seems, however, to be the fact, since the greater breadth of land by their means laid open to market, and the resulting general wealth have enabled all to keep pleasure-vehicles, when formerly the saddle only was used outside the stage-coach. The plain springless box-wagon of the farmer conveyed his family to and from church on Sunday, and hauled his produce on week days, until within a very few years, when the idea of extravagance attached to the possession of pleasure or spring-wagons began to give way, and those vehicles were found in the carriage-house before the piano supplanted the quilting-frame in the parlor. So far from a decrease in horses, new ones and of better breed were required for fast and stylish driving. The well-to-do, permanent business man must have his business-wagon of tasteful appearance, case-hardened iron axles, steel springs, and a top buggy. A rockaway, or even a coach, in many cases, is required in addition, and furnishes labor for fancy horses. The multiplication of vehicles is caused on one hand by the greater means of the people, and on the other hand by the great improvements in manufacture, which have diminished the prices while they raised the quality of the almost infinite variety of styles offered. These are so admirable as to have elicited not only the surprise, but what is better, the custom of the citizens of Europe. The tide of improvement ran naturally at first in the line of stages and coaches. The object was to make them strong and light, and with such proportion of all the parts as would facilitate the draft; in other words, to avoid loss of the power of the horse. In the cities the improvements are of recent date, and arose out of the magnitude of the business. The style adopted in 1830 was the omnibus or long coach. One vehicle was then started to run up Broadway for 12½ cents per head. The success was complete, and the number multiplied, while the fare fell successively, until at the present time the most successful charge 5 cents in common with the rail-cars. The number of omnibuses now running in New York is 440, and the use of them has spread all over the country, giving birth to very numerous and extensive factories for their produc-

tion. About 300 per annum are made in New York, and larger numbers in Newark, New Jersey. The experience, skill, and capital that had been applied to the production of the old post-coaches were applied to the construction of the new vehicles. The work to be performed by the coach requires the utmost care in the selection of the materials and in the manner of combining them. The frame is a piece of the nicest joiner's work, of the toughest ash, that has grown in exposed situations, and been seasoned at least two years. For some portions, oak and hickory, equally well selected, are used. The planking is of the strongest elm, and the panels of Spanish cedar; mahogany and rosewood for ornamental portions. The frame and axles are thoroughly ironed with the best metal. The springs are of the best steel, and of these many of the improved forms are of quite modern dates. The elliptical spring was introduced in 1825. The leather is of the toughest and finest description. The upholstery of fine cloths, nets, damasks, plushes, with coach-laces, extensively manufactured in New England. The most important part of the construction is probably the wheels. These must be so put together as to give the greatest amount of strength with the smallest weight of material. For this purpose the felloes are of ash, the spokes of oak, and the nave of elm. All these are so arranged as to receive the weight of the coach as far as possible longitudinally of the fibres of the wood. A very important American improvement in the strength of the wheel took place some 30 years since. Up to that time the iron tires had been put on in separate plates, breaking joints with the felloes. An American blacksmith conceived the idea of making the tire whole and driving it on when hot, so that its contraction as it cooled would bind the whole wheel together almost as one piece. This invention has been universally adopted. The tires of New York omnibuses are, when new, an inch thick; but so great is the wear, that they require renewal in 4 months. The size of the wheel is regulated by the ease of draft. Thus it is found that the greatest ease requires that the line from the centre of the forward axle to the shoulder of the horse should form an angle of 15 degrees with the horizon. This principle will not admit of the fore wheels being more than forty-four inches in diameter, while to diminish the draught, the hind wheels are 56 inches, and the width of track is 4 ft. 8 in. The naves of the wheels have a lining of metal, forming a box that excludes dust and retains oil.

It will have been remarked by the observing reader that, in every branch of industry which has been recently taken hold of by the American manufacturer, the facility of production and cheapness of sale-prices have hand in hand made rapid progress. This remarkable feature has been due mostly to one principle: it is that of reducing the manufacture to its utmost subdivision, and making a distinct branch of each separate part of the object to be completed. A pattern being once fixed upon, all the parts of that pattern are given out to workmen, who confine themselves each to the manufacturing of the part he undertakes. The parts so produced are made in the best manner. Each man strives to improve in the work, or to do more and better in a given time, and his native intelligence does not fail of results. The products of all their labors are then combined in complete articles in number and quality to defy competition. This mode of manufacture is a cause and a consequence of large sales. By improving and cheapening the goods the demand is increased, and thus reacts upon the power to produce. The carriage manufacture is another illustration of this principle. The Messrs. G. & D. Cook & Co., of New Haven, when they engaged in the manufacture, nine or ten years since, introduced this way of systematizing the work. The mode of building carriages then was for each man to have a hand by turns in all the processes until the manufacture was completed, and that was of uncertain time. The Messrs. Cook were enabled by this plan to turn out a complete carriage in a day, of a quality which enhanced the admiration that the time of the operation had awakened. Their business has gradually expanded, until they now turn out ten per day, with the same facility with which they formerly turned out one. The engraving on another page gives an idea of the extent of their establishment, which covers two acres, and affords 85,000 square feet of floor room. It has grown to this extent from one building, on one third of an acre, with 3,000 feet of floor room. There are in the concern 24 separate departments, under 24 distinct foremen, each of whom is responsible for the part of the work performed in his department. All of them cover every branch of

the business, from the rough lumber to the boxing up of the complete vehicle. The orders are all laid before Mr. Kimball, one of the firm, and by him 24 blanks are filled up with minute particulars of the jobs delivered to each foreman, with the time specified for the completion. These foremen have 300 workmen employed in all the departments, each of which is also supplied with every variety of machine that invention and experience have suggested to facilitate the work, and these are driven by a steam engine of great power. This huge giant with its thousand arms obeys every movement of the 300 human workers, and the surprise of the observer who sees rough lumber wrought up into pleasure-wagons at the rate of *one an hour* is merged in admiration of the intellectual combination that produces such results.

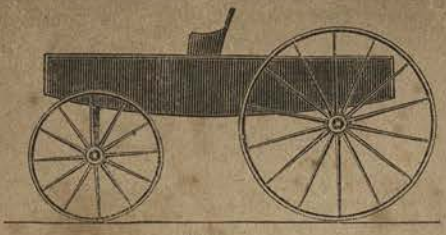
It is such enterprise and success as this that drew from the London Jurors of the World's Fair, the following remarks in their report: "Comparing the state of the art of carriage-building," say the London Jurors, in their report on carriages exhibited at the World's Fair, "of former and not very distant times, with that of the present, we consider the principles of building in many respects greatly improved, and particularly with reference to the lightness, and a due regard to strength, which are evident in carriages of British make; and especially displayed in those contributed by the United States, where there is commonly employed in the construction of wheels, and other parts requiring strength and lightness combined, a native wood (upland hickory), which is admirably adapted to the purpose. The carriages from the continental states do not exhibit this useful feature in an equal degree."

The woods most used in the construction of carriages, ash, oak, and hickory, grow of superior quality and in great abundance in the neighborhood of Philadelphia, and the fact gives the art of carriage-making there great advantages. There are in that city over 30 factories that produce pleasure-carriages. The capital invested is some $600,000, and over 800 hands are employed. The vehicles are mostly for city use, with some export demand. One of the largest factories of the city, Roger & Co., occupies 40,000 feet of work room, and employs 125 men in all the departments of designers, body-makers, wheelwrights, carvers, painters, platers, trimmers, upholsterers, etc. The wagons of that establishment have a good reputation. In New York, the carriage business is pushed to a great extent. The demand for heavy vehicles for the great cities is large, and the effect of railroads, in spreading the population of the city over a radius of 40 miles around it, has caused a considerable demand for pleasure-wagons. Some persons who would have no use for a vehicle in the city, in adopting a suburban home, found a carriage a necessity. The aggregate of the business in the state of New York in 1855 was given by the state census of that year as follows:—

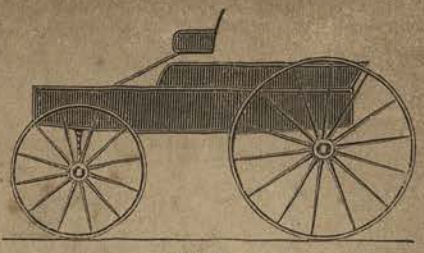
CARRIAGE AND CAR MANUFACTORIES IN NEW YORK.

	No.	Hands.	Capital in tools.	Value of materials.	Value produced.
Felloe factories	6	30	$13,250	$21,450	$45,174
Wheel "	2	12	3,500	2,800	11,100
Hub "	1	5	600	400	9,000
Spoke "	16	64	15,950	14,966	52,331
Coach and wagon factories	1,397	6,391	471,530	1,712,256	5,005,125
Car factories	26	1,547	264,784	679,239	1,274,768

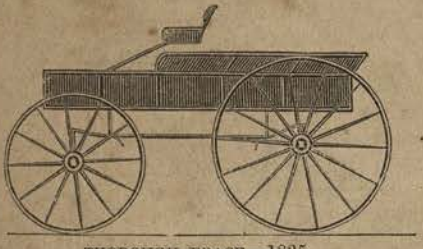
The number of cars made per annum, is 580, and there are used 1,472,000 feet of lumber in their construction, and in that of wagons, 6,562,200 feet. There are 11,151,500 spokes made. The number of wagons turned out, is 33,138, and of sleighs 3,838. The size of some of these factories, and the number of vehicles turned out, are surprising. The numerous depots for carriages in the city, contain every possible description of vehicles, and of all manufactures. The carriage manufacture in New Jersey stands next in magnitude to that of New York. This is mostly at Newark, where great numbers are turned out, of an approved quality. A feature of the carriage and wagon business that has been introduced of late years, is that all possible parts of vehicles can be purchased in any quantity, consequently the wheelwright business of small towns has been entirely revolutionized. They can no longer make an entire vehicle as formerly with any success, but purchase wheels, axles, top frames, springs, etc., of any and every pattern, to put together and finish. All these parts are produced in great quanti-



1810.



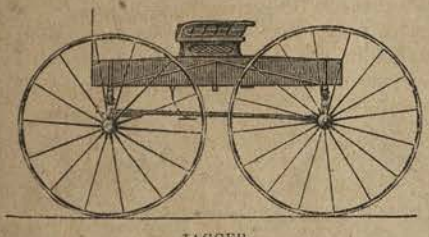
1820.



THOROUGH BRACE—1825.

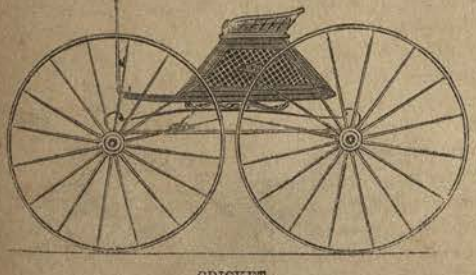
FIRST ELLIPTIC SPRINGS.

The following are a few of several hundred styles manufactured by Messrs. G. & D. Cook & Co. at the present time.

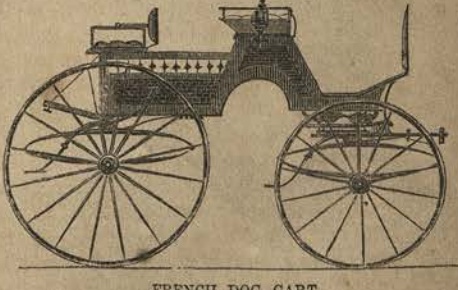


JAGGER.

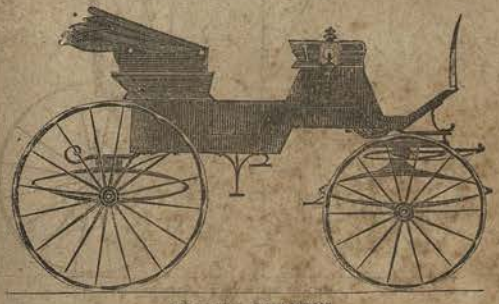
GAZELLE.



CRICKET.



FRENCH DOG CART.



ENGLISH PHAETON.

BOX JUMP SEAT.

WORLD'S FAIR BUGGY.

EUREKA JUMP SEAT.

CHILD'S SEAT DROP FRONT.

CRESCENT CITY.

LAWRENCE BRETT.

LOOP CALASH.

DOCTOR'S PHAETON.

FULL TOP CABRIOLET.

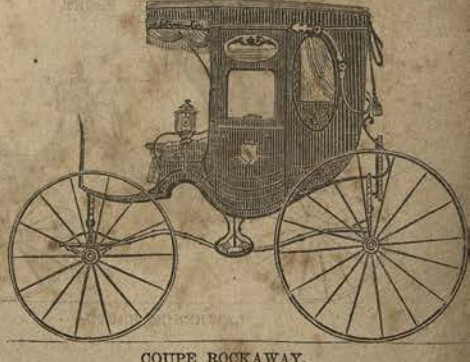
CHAMPION.

PRINCE OF WALES

DAYTON BRETT.

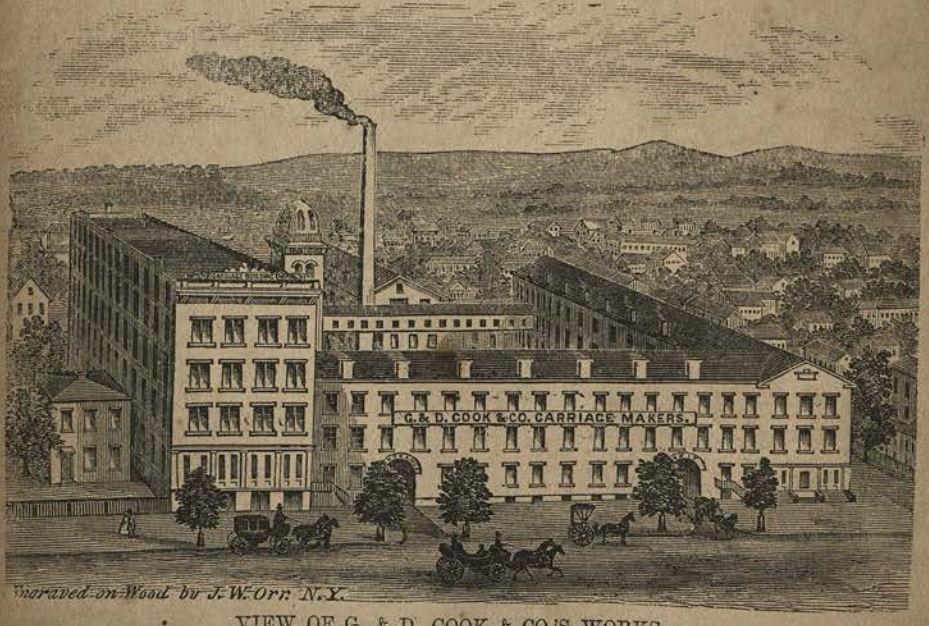
CITY COUPE.

BREWSTER CALASH COACH.



COUPE ROCKAWAY.

PREMIUM TOP.



VIEW OF G. & D. COOK & CO.'S WORKS.

ties, by machine. Hence, as we see, there are in New York, 16 spoke factories, which turn out 1,115,500 spokes per annum, also felloe factories and hub factories, etc. The largest city factories, however, make most or all the parts within themselves. In the production of a vehicle, the design is first prepared, whether buggy or coach or rockaway, on paper, $\frac{3}{4}$ of an inch to the foot. The design being approved by the purchaser or owner, a geometrical plan is executed upon the black-board. The patterns are then cut in the wood, and from this skeleton the shape and proportions are determined. There must be exercised in this process, the utmost mathematical exactness. The wooden frame is now removed to the smithy; then come in requisition, springs, tires, hinges, axles, bolts, locks, and every variety of form by which iron can conduce to the strength of the fabric. This being completed, the skeleton is moved to the body department, to receive its floors and panels, the sides with their proper curvature, the seats of the destined construction, and the doors with their trimmings. From this room, the body goes to the paint room. This is a tedious process. From 15 to 18 coats of paint are applied, each being rubbed down with pumice stone. When it is dry, several coats of white lead and litharge, succeeded by a number of white lead and yellow ochre, complete this "priming," on which the finishing coats of ornamented colors are charged. When it is clothed in its pride of paint, it seeks the trimming-room, to be decked with fine cloths, silks, lace, carpet, embossed leather, or the finest morocco, and becomes as tasteful as art can make it. While the body of the vehicle is thus being prepared, the carriage, or wheels, axles, perches, and shafts have also been approaching a state ready to receive it. The felloes, shafts, and nave, each of its appropriate and well selected wood, are combined into wheels, that must in size bear a certain proportion to the body. The average difference between the fore and hind wheels is eight inches. In the combination each department supplies its proper part, and when ready to receive the body, that is hung upon the springs, and the whole is ready for the final polish. Apart from the coach or pleasure-vehicle business, is the wagon business, which is of great extent, all the parts being formed by machines of late invention. The lumber for these heavy vehicles is of considerable dimensions. The plank used is three to four inches thick. This must be all well seasoned. Hence capital is required to keep a sufficient stock on hand, since it requires four or five years to season, or one year for every inch of thickness. The timber for hubs is of black locust. This, of different sizes, has the bark removed, and is bored through the centre to facilitate the seasoning. All the lumber thus seasoned in stock, is, when ready, removed to the saw mill. Here machines are usually ready to shape every part: upright and circular saws to cut the plank into shafts and felloes after it is marked; planing machines, and mortising machinery; lathes for turning spokes and hubs; for boring holes for the spokes; for driving in the spokes; for shaping and finishing the felloes; for boring holes in the hubs to receive the boxes, so as to insure a solid bearing, and for turning the hubs, of which the two ends are cut off at once by circular saws. All these machines soon turn the solid plank into finished wheels, while the body is growing under similar applications in another room, under the direction of various departments. The iron axles are turned in the machine shops, where also all the tires, bands, straps, bolts, rivets, etc., are prepared and applied. The wagons are then ready for the paint. This is the general operation of wagon-making in large establishments. In Philadelphia two concerns furnished 550 wagons for the Utah expedition of the government in five weeks, or at the rate of 16 wagons per day, or a wagon in 45 minutes.

The demand for Express wagons that has grown up of late years, has become very large, and they are produced in great perfection as respects strength and price. Another large demand for vehicles has taken the shape of railroad cars, and those almost rival coaches in the extent of manufacture. In New York, the value of production is nearly $1,500,000 per annum, mostly at Troy. The car wheels are of iron, and the utmost care is taken in the manufacture of them, that when cast the iron shall cool equally in all its parts. For this purpose, when the wheel is cast in a mould, it is removed as speedily as possible into a circular chamber or furnace, composed of fire brick, $4\frac{1}{2}$ inches thick, and surrounded by an iron case. When they are there deposited, the opening is closed, and the heat of the whole is raised to nearly the melting point. All the avenues to and from the interior are then closed, and

the whole is left to cool gradually. By this process of raising the heat, the temperature of the wheel is equalized in all its parts, and as the heat can then only subside through the wall, it cools so gradually that all parts of the wheel contract alike. For this cooling 4 days are required. While red hot the wheel is removed, and having its edges packed round with sand, the centre is made to communicate, by means of a flue, with a chimney 120 feet high. The draught thus created cools the centre. The same, if not far greater importance attaches to the uniform toughness of the iron of a wheel as to that of a cannon. The lives of hundreds of passengers are always depending upon the soundness of the running wheels, and the utmost care is taken to make and keep them sound.

The census of the United States, for 1850, gives the following figures, in relation to the Carriage and Wagon Manufacture of the Union. The figures of course represent only what the industry was ten years ago, since when the largest factories have been started, and the greatest expansion given to enterprise in that direction. It is probable that the census of 1860, when its return shall have been made public, will disclose at least double the value here indicated.

	Establishments.	Capital.	Raw material.	Hands.	Labor.	Product.
Coaches	1,822	$4,973,707	$3,955,689	14,401	$4,268,904	$11,073,630
Wheelwrights	4,226	3,146,211	1,886,351	11,549	3,157,544	6,827,451

CLOCKS AND WATCHES.

PERHAPS there is no one article of more general utility than "Yankee clocks," and none on which more small wit has been expended both at home and abroad. The land of "wooden clocks and nutmegs" has been a standing jibe against those who have so cleverly and perseveringly executed those practical ideas that tend directly to the amelioration of the human condition. When we look around and reflect that every house, hut, and hovel in the length and breadth of the land is, or can be, supplied with an accurate time-keeper for one dollar, that is to say, a bushel of grain, and reflect that thirty years since comparatively no time-keepers existed within reach of the masses of the people, we begin to perceive that Yankee clocks are by no means so contemptible a commodity. Doctor Franklin demonstrated that "time is money," but the people at large had no more means of measuring their time than of money to count. Alfred the Great and other old progress men discovered the value of time, and were hard put to it to measure it out. Some of the old fellows sought to do it by the dropping of water; many marked the progress of the sun; and other devices were employed without very great accuracy. Alfred contrived twelve candles, which being burned one after the other, divided his day into twelve portions, which had each their special employment. Twelve candles were not convenient, however, to carry in one's fob, and were troublesome to light and snuff. If a Yankee peddler had walked in upon him with a wooden clock under his arm to sell for a dollar, he would far more likely have been hanged as a wizard than sneered at as a humbug. Time-keepers were invented, however, in the process of time, and gradually found their way into the hands of the rich. They were imported into this country from Europe down to the formation of the federal government, at high prices. Some of these were the pendulum clocks, some six feet high, and generally stood in the landings of the old houses. About the time of the formation of the federal government, however, Eli Terry, of Windsor, Connecticut, made some clocks of wood, of a small size, to hang up against the wall. In 1793, he began making them, as a business, in Plymouth, Connecticut. Then he made a few in the year by his own labor. In 1800 he had procured the help of a couple of young men. The wheels were marked out on the wood with square and compass, and then cut out with a fine saw and jack-knife, the teeth of the wheels being formed in the same manner. Twice a year Mr. Terry would pack up some of these clocks and make a journey into the new country, by which name the region west of the North River was then called. There he found sale for his wooden "movements" at $25 each. He so prospered in this, that by the year 1807 a number of persons in Waterbury associated themselves into a company to furnish Terry

with stock of which he was to make the movements. To execute this formidable work, he bought an old mill, introduced some machinery, and laid out a lot of 500 clocks at one time, a larger number, it is said, than was ever before undertaken at one time in the world. Mr. Terry used to sell his clocks himself at a price of $25, but of course money was not then obtained. Salt pork was currency, and when he took the clock out of his saddle-bags, he put salt pork in the place of it. In 1810, Mr. Terry sold his factory to Thomas & Hoadley, and competition springing up the price of the wooden movements was reduced from $10, the then price, to $5, at which low price some of the manufacturers failed. In 1814, Terry invented a new style, called the pillar scroll top case, about 21 inches high. These sold for $15 freely, for many years, and he made a fortune of some $200,000. At this juncture Chauncey Jerome became an apprentice to Mr. Terry, and the works being extended, a circular saw was introduced for the first time, and it was a great curiosity. Jerome began when of age to make a few clocks for himself, and sold them at $12 each. He continued the business under many vicissitudes, making large quantities of clocks that were sent all over the Union, and sold by means of peddlers. An occasional new form to the clocks gave a renewed impulse to the sales, the growing competition between the clockmakers continuing to force down prices. The panic of 1837 had a disastrous influence upon the trade, ruining almost all the manufacturers. Up to that time the clocks had been altogether of wood, of which it was difficult to procure the right description. When this was obtained it required a year's seasoning, and then it was a slow process, even with machines, to cut out the works. The largest manufacturer had never made more than 10,000 per annum. These clocks were one-day clocks, but good time-keepers. In 1837, Mr. Jerome invented the one-day clock with brass works. This invention proved a new era in the clock business, and buried the old wooden works. From that time the business made very rapid progress, and the clocks not only found their way all over the Union, but also to Europe, India, China, Australia, and elsewhere. The old wooden clock could not well be exported, because exposure to the humidity of the ocean air caused the works to swell in a manner that ruined them. This difficulty the brass works did not encounter. The new business improved very rapidly under the demand for the clocks, which was continually stimulated by the gradually falling prices. The old wooden dial was supplanted by one of zinc, and an eight-day clock, which would have cost $20 in 1837, can now be had for $4. The one-day clock is sold for 75 cents, and is an excellent time-keeper. The brass works of the clocks are made from the metal sheets with the greatest rapidity. The oldest manufacturer, Mr. Jerome, states that three experienced men can make 500 clocks in one day from the sheets. There are in every one-day clock from 8 to 10 wheels; an eight-day clock requires more. All these wheels are cut from the brass at one operation, pressed out and levelled for use. The expense of three days' work is thus distributed through 500 clocks, not quite 1¼ cents each clock. The whole cost of the movements was 50 cents each. The frames of the clocks are also made in large quantities by machine. For the body of the case, common merchantable pine lumber is used. The boards are by circular saws cut into suitable lengths for sides and tops. Those free from knots are then by another saw cut into their proper widths, and go to the planing machine. They then are by an appropriate instrument cut in the shape designated for the fronts. The pieces are then taken by a workman who spreads glue upon them, to receive the rosewood or mahogany veneer. These are then in lots of a dozen placed in hand-screws until dry. When ready, the veneer is polished by applying it to a revolving cylinder covered with sand paper, by which it is soon sufficiently polished to receive the varnish, of which several applications are made, and it requires about ten days to dry. They then receive a polish and are put together in the form of the case. It was usual to have 10,000 clocks undergoing this process at once. In this manner a case would cost 50 cents, 20 for labor and 30 for stuff; a cabinet-maker could not make one such under $5. The dials are cut by machinery from sheets of zinc, the holes being punched by the same operation. They are then painted and the letters and figures printed on. One man could print 1,200 to 1,500 in a day. The whole dial would thus cost 5 cents. The tablets printed in a similar manner, and colored by girls, cost 1½ cents each. The

glass and work 4 cents. The weights cost 13 cents. Thus the complete clock would cost about $1.25, a price brought about by the systematizing of the labor.

The great clock factory of Chauncey Jerome was one of 31 that were in operation in 1852. It had been merged into a joint-stock company in 1850, called the Jerome Manufacturing Company. In 1853 and 1854 that concern produced 444,000 clocks per annum; another factory, that of J. C. Brown, produced 100,000 clocks per annum, and failed subsequently; and the Ansonia Company, which was afterward formed, 150,000 clocks per annum. The sharp competition of all these companies reduced the price to such a degree that many stopped. In the ten years ending with 1856, four factories were destroyed by fire, nine failed, and five closed on account of low prices. There remained 13 factories, of which six produced 95,000 per annum, and the remaining seven, 48,000 clocks. In 1855 the great showman, Barnum, became a member of the Jerome Clock Company by selling a clock factory which he owned in Bridgeport to the Jerome Co., and taking stock of the company in payment. In the same year the Jerome Co. failed utterly; its owners allege, because the debts of the company bought from Barnum ruined them, while the assets of the concern were of no value, and the extensive financiering to stave off these liabilities, swallowed up all the means of the Jerome Company. The result was almost a complete sweep of the clock business. The New Haven Clock Co., which succeeded to the business of the Jerome Co., is now the largest factory. Its method of making dials, etc., is the same as was that of the old company. There is also the Benedict & Burnham Co., at Waterbury, Conn. The factory of Seth Thomas & Co., at Plymouth, is the next largest. The factory of William L. Gilbert, of Winsted, is also important. The factory of E. N. Welsh, of Bristol, is the successor to the business of J. C. Brown, who failed. These five companies now make most of the clocks manufactured in Connecticut. The New Haven Co. produces about 200,000 per annum, and the other four companies about 300,000. There are other parties engaged in making clock movements and parts of clocks, and one house in Bristol makes thirty-day brass clocks that keep excellent time.

From Connecticut, by the perseverance of these energetic men, the clocks have spread over the face of the whole country, ticking in almost every store and dwelling of the Atlantic cities, and almost every log hut of the frontier. Nor have they been confined to this country. In 1841 they were introduced by Mr. Jerome into England, exciting there great surprise and indignation at the presumption of the Yankees with their wooden tickers. The tariff laws of England permit the owner of goods to enter them at his own price, on which the duty is to be cast. If the officer thinks that price too low he can take the goods at 10 per cent. advance on it. The first cargo sent by Mr. Jerome were entered at regular prices, but these appeared so ridiculously low to the officer that he paid the 10 per cent. and seized the goods. The owners, nothing loath, brought forward another lot, which met the same fate; but on presenting the third the officer had become a wiser man, and let the Yankees do their own business. Jerome's clocks had there a great run, and they also tell the time to the people at Jerusalem and Joppa. The Chinese have been taught to use them, and a Yankee clock marked the time when the emperor fled from Pekin.

While Yankee clocks have had such an extensive and important run during the present century, the making of watches has been undertaken only within the last ten years. The originator of the business was Mr. E. Howard, of Boston, and a successful business is carried on at Roxbury, Massachusetts. A distinctive character of these watches lies in that part of the watch which constitutes the main feature of difference between the English and Swiss watches, and which gives to each its national characteristics, so far as the principle of their construction is concerned. In the English watches, the motive power is conveyed to the train or wheel-work by means of a chain and fusee; in the Swiss watches, the motive power is conveyed to the train directly by means of what is termed the "going barrel." In the American arrangement, is employed neither the fusee nor the going barrel, but the stationary barrel, in combination with the maintaining power. The stationary barrel has indeed been found in watches made a hundred years ago; but in all such watches the stationary barrel is very impractical, as they are minus the maintaining power, and

are consequently liable to stop while being wound up. But by the direct application of the maintaining power to the fixed barrel, are obtained several very important advantages over the chain and fusee, and also over the going-barrel arrangement. These facts add much to the character of American-made watches, and in point of nationality, afford features of difference to distinguish them from the foreign watches.

The perfection with which machinery is adapted to fine work, is beautifully illustrated in the works of the Waltham Co., which we believe is the only one in the world where all the parts of the watch are perfected under one roof, and systematized so that all the parts of one will fit any number of others. The different parts of the mechanism of foreign-made watches are cast and cut laboriously by hand, separately, and often in places remote from each other, then sent to the finisher's to be polished, fitted together, and set up. Not only does this arrangement involve a vast amount of expense for the time and labor employed in the execution, but it necessarily results that no two of these pieces can ever be so precisely alike as to render it possible to substitute one for the other, and that the whole mechanism, made thus in different places by skilful, mediocre, and inferior workmen, can never be adjusted with the same precision as though manufactured in one establishment, under the supervision of a single head. These difficulties have been obviated by the American Watch Company. Every part of the watch is cut in their establishment by the aid of machinery, graduated to microscopic exactness, and working with a delicacy of touch that the fingers would strive in vain to emulate. The pieces are thus cut exactly alike. The jewelling department in this establishment is under the direction of the most skilful artisans. The precious stones, rubies, sapphires, or chrysolites, inferior only to the diamond in hardness, and resembling grains of brilliant sand, are drilled by the diamond's point into pivoted reliances. They are then opened out with diamond dust, on a soft, hair-like iron wire, their perforations having certain microscopic differences. In like manner, the pivots of steel that are to run in these jewels, without wearing out in the least, must be exquisitely polished. By this operation their size is slightly reduced. The jewels and pivots, after being thus finished, are classified by means of a gauge, so delicately graduated as to detect a difference of *the ten thousandth part of an inch*. The jewels are classified by means of the pivots, the jewels and pivots of the same number fitting each other exactly. The sizes of the several pivots and jewels in each watch are carefully recorded under its number, so that if any one of either should fail in any part of the world, by sending the number of watch to Waltham, the part desired may be readily and cheaply replaced with unerring certainty.

By the old method, the processes of boring holes and shaping wheels and pinions, and bringing them to a size, were done by the drill-bow alone, a slow method, and depending wholly on the quick eye and steady hand of the workman, who only acquired the requisite skill by long years of apprenticeship. At Waltham, all this is done by lathes connected with a steam-driven shaft, and the boring or cutting tools guided by machines of most ingenious contrivance, so as to make the pieces absolutely uniform in all their dimensions.

Take, for instance, a pinion, which is made out of the solid steel wire drawn for the purpose. Some of this is drawn plain and some with grooves for the teeth. In either case, the arbor or axle is turned to the exact size and taper required to fit the holes in the jewels, and the teeth cut to their shape and distance, all by various machinery, and with such absolute uniformity that any one piece will fit to its place in any other watch of the same pattern. In like manner, the stones for pivots are first cut, and then rounded and brought to a size, polished, and fitted for use by machines, tended by young women, who acquire the requisite skill by a few weeks' practice. Little screws, so minute that it takes one hundred and fifty or two hundred thousand to weigh a pound, are cut from the wire with surpassing rapidity, threaded, and the heads finished with complete accuracy.

The tools and mechanical movements by which all these results are so completely accomplished, are nearly all of original contrivance, and if fully and scientifically described, would excite general admiration for their ingenuity.

The works admit of the employment of 220 hands, and can turn out 50 watches per day. Of about 125 pieces that go to make a watch, some pass through 50 hands before they are finished.

ELECTRO-PLATING.

It is now scarcely a score of years since this wonderful art began to attract attention, and it has become of great importance in many departments of industry. By its means an exact copy of any surface may be obtained in a metallic layer, as of a page of type, a medal, or coin. This impression obtained, being backed with more fusible metal, becomes a duplicate of the original article. This branch of the art is called electrotyping, and some account of it is given in respect to type elsewhere in this volume. The other branch of the art, by which the metal held in solution may be made to settle upon and to cover permanently the surface of objects ornamental and otherwise, is called electro-plating or electro-gilding. The discovery that this might be done was made early in the present century, but it was not followed up as a useful art until 1839, when Mr. Jordan published an account of the manner in which he obtained impressions of engraved plates and other matters. Attention was then directed to it. Previous to 1836 silver-plating or gilding was executed in the old way or various ways. Iron was gilded by polishing its surface and then heating it till it acquired a blue color. When this was done leaf gold was applied, slightly burnished down, and exposed to a gentle fire, after which it was burnished again. Copper or brass may be gilded in the same manner. Gilding metals by amalgamation was effected by forming the gold into a paste or amalgam with mercury, and was chiefly employed for gilding silver, copper, or brass. The metal being well cleaned, is dipped into the amalgam or spread over with it, when a quantity will adhere to the surface. The metal is then exposed to the heat of a furnace, which volatilizes the mercury, leaving the gold adhering; this is afterward burnished. In this way buttons and similar articles are gilded.

Ornamental figures may also be delineated in gold upon steel by a very ingenious process, by means of ether. Gold is dissolved in nitro-muriatic acid, and a quantity of ether is added, and the mixture shaken. The ether will then take the gold from the acid, and an ethereal solution of gold will be produced, which is separated and applied to the surface of the steel by a camel hair; the ether will evaporate, leaving the gold on the surface of the steel. The metal is then heated and the gold burnished. In this way sword-blades are ornamented. Instead of ether the essential oils may be used.

Making gilded trinkets was brought to such perfection that the use of real gold was very much diminished. The most elegant patterns are struck in thin copper, and then gilded so perfectly as not to be distinguishable in a general way, while new, from gold, and with proper care they will last for a considerable time; but when the gilding does wear off, the color cannot be restored, as in the case of jeweller's gold. These were the processes in use up to 1836, when Mr. Ames was one of a committee sent to England by the government to acquire knowledge in aid of a government arms manufactory, and his attention was attracted to the subject of depositing silver by electricity, which was then being discussed, and its theory established. No process of depositing the silver upon any base metal, as german-silver, had been discovered. Subsequently, pursuant to some suggestions of Professor Silliman, it was discovered that prussiate of potash would hold the silver in solution without oxidizing the baser metals. This removed a part of the difficulty, but there yet remained to deposit any given weight of silver that might be required. This was also removed by the discovery of the cyanide solution. From that time the art of depositing the precious upon base metals gained ground, and has since become important.

The early process was to dissolve sulphate of copper in a vessel, and to suspend a zinc plate by wires soldered to it, and the object to be coated by the same wires in the liquid facing the zinc and very near to it. On the application of the electric battery, the zinc dissolves, and about the same amount of copper deposits itself upon the object to be coated, which is attached to the negative pole of the battery. A quantity of sulphate of copper is suspended in bags in the upper portion of the liquid to supply that which deposits. In electro-plating with gold or silver there should be a constant motion sustained, in order to aid in equalizing the deposit. In plating, the utmost care is to be taken to remove all traces of grease by boiling the object in alkali. This process is extensively employed for giving a very thin coating of silver to german-silver, britannia, pewter, or brass, by which they have all the apparent beauty of the precious metal. The mode of dissolving the silver

was originally by pure nitric acid; distilled water then being added, the silver is precipitated as a cyanide by a solution of cyanide of potassium. The precipitate being collected and washed, is dissolved in a solution of cyanide of potassium, and this is used for silver, in place of the sulphate of copper used for the deposit of that material. The object is more conveniently obtained by connecting a plate of silver with the positive pole of the battery, suspended in a solution of cyanide of potassium, and allowing the current to pass until the silver begins to deposit upon the negative pole. To insure the adhesion of the silver to every part of the object to be coated, it is well washed in an alkaline lye. The copper wire is then attached to the object, which is dipped in nitric acid, and then placed in the solution; after being in it some minutes it is taken out and well brushed with sand. It is then replaced in the solution, and in several hours' time it will have acquired a coating of dead white silver as thick as tissue paper. It may then be burnished or polished with a hard brush and whiting. The strength of the battery makes a difference in the hardness of the silver. When the battery is weak, the deposit is soft, and it hardens with the increase of the magnetic strength, accompanied by continual motion, which also equalizes the deposit up to a certain point, beyond which the silver changes to a black powder. To produce the natural hardness of the hammered metal, it is requisite to preserve certain proportions between the size of the silver plate, and the object to be plated. If the time of the operation is prolonged, the deposit may be thickened to almost any extent. To deposit a plate as thick as ordinary writing paper, will require 1¼ or 1½ oz. of silver to 12 square inches. The pure metal thus deposited is as durable as that used for silver coin. By the electro-plating process all ornaments, however elaborate as designs, however complicated they may be, can be produced as readily and in as great perfection as in solid silver. The most elaborate epergne or the plainest tea or dinner-set is wrought and plated in the perfection of the purest silver. Door-plates, knobs, bell-pulls, cutlery, etc., all come within the scope of this rare art. The manufacture is carried on in New York, New England, and Philadelphia, on a great scale; but perhaps the house of Rogers, Smith & Co., of Hartford, the first that engaged largely in the business, has retained the relative magnitude of its position. Their manufactory is a very extensive one, employing many hundreds of hands at the same time. They make more than fifty different patterns of tea-sets, and their ware excels in richness and durability. Their ware has found its way into private families, hotels, and steamboats to a considerable extent, and also swells the volume of the national exports.

In electro-gilding the metal is dissolved in nitro-muriatic acid, when the chloride of gold thus obtained is digested with calcined magnesia. The oxide precipitated is washed by boiling in nitric acid, and is then dissolved in cyanide of potassium. The temperature in gilding copper should be at least 130° F., and in gilding silver still higher. The positive plate of the battery must be of gold, and the negative of iron or copper. Some of the metals, as iron, steel, lead, do not readily receive the gold in deposit (unlike banks in that respect), but, being first covered with a light coat of copper, the gold is deposited upon that. The copper may be said to act in this case like the mordant in calico printing. The solution should contain as much gold as will perfect the desired work at once. In this operation the smallest quantities produce the most extraordinary effects. The almost infinite malleability of gold is well known, and its capacity to "spread itself" upon properly prepared metals beats that of a 4th of July orator. An ordinary watch-case may receive a heavy coat on the outside and be well covered within, and yet the expenditure of gold will be only 20 grains, or the value of one dollar. "A magnificent gold pencil-case" will have cost 3 grains of gold, or 16 cts. worth. The expense of tipping a taper finger with gold for sewing is 5 cts., and probably that is all it is worth since sewing-machines have laid both thimbles and sailors' palms upon the shelf.

It is easily understood that the introduction of such an art as this should have at once superannuated the old system of plating. Progress is being continually made, and in New York machines have been introduced and applied to practical operation in electro-plating.

FISHERIES.

THE fisheries, as we have elsewhere shown, were the first successful industry of the col-

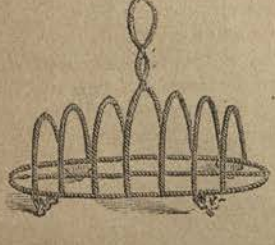
onies, and they laid the foundation of our national commerce and marine. The results are not singular in this respect, since the most flourishing commercial countries of the modern world owed their origin, like the Romish church, to the "poor fisherman." When the subjects of ancient Rome, flying before the hordes of Attila, retreated to the lagunes of the Adriatic, nothing remained to them but the sea and its treasures. This pursuit enabled them to rear on the rocks that had sheltered them, the proud Venice which awed the world, and whose power fell only when the republic had become a corrupt oligarchy, and the young general Bonaparte, the agent of a new republic, called them to account. With the same origin Genoa grew into the dominion of the seas, and encountered the same fate when wealth and corruption succeeded the humble virtues of the founders. The Dutch, from a band of herring-catchers, whose collection of fishing huts was called Amsterdam, carried on that system of energetic industry that conquered Holland from the sea, and prevented the future encroachments of that element by dikes; while the country grew rich and so powerful that the successors of those old herring-busses carried a broom at the mast-head in token of the sovereignty of the seas. To them succeeded the English, whose fishing-nurtured marine, coupled with an aptitude for commerce, gave them the mastery over the wealth-enervated Dutch. The English felt the maritime sceptre to tremble in their grasp for the first time, when the New England trained fishermen met them in battle, and almost every engagement resulted in the triumph of the "bit of striped bunting." But warlike supremacy is the least of the triumphs, since the commercial and maritime superiority has every day become more manifest, from the moment Paul Jones "began to fight" and "old Stewart" out-manœuvred the Engish fleet, to the success of the yacht America in the British waters. In that period the Yankee fishermen have carried the stars and stripes to every corner of every continent and shown them to every isle of the ocean. The vigor and address with which the New Englanders early embarked in the cod and mackerel fishing, and built vessels with which to prosecute it, not only excited the admiration of the mother country, but roused the alarm of the government, who foresaw, in their industry and intelligence, the causes of the defeat they sustained a century later.

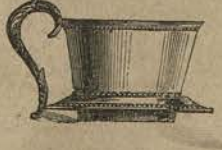
About the time of the Declaration of Independence, the trade growing out of the cod fishery furnished the northern colonies with nearly one half of their remittances to the mother country, in payment for goods. All the seaport towns were engaged mostly in it, and thus grew in proportion to the success of that business. Under these circumstances, the fishing rights were a very important part of the negotiations entered into at the peace. The general result of the negotiations was that the Americans might catch fish anywhere except within three miles of certain English colonial coasts, and might land to dry and cure on the southern side of Newfoundland and other convenient coasts. Congress, by law, also granted a bounty to vessels of which all the officers and three fourths of the crew were American citizens. The bounty was altered from time to time, and as it now exists under the law of 1855 is as follows: If the vessel is more than five tons and not more than 30, $3\frac{1}{2}$ per ton; more than 30 tons, $4. The allowance of one vessel during the season, whatever may be her tonnage, cannot exceed $360. The bounty paid out in the last 12 years amounts to $4,046,929, or $337,244 per annum average. The whole amount paid since the formation of the government has been $12,944,998, and the following states were the recipients:—

STATES THAT RECEIVE THE FEDERAL BOUNTY.	
Maine	$4,175,050
New Hampshire	563,134
Massachusetts	7,926,273
Connecticut	182,853
Rhode Island	78,895
New York	18,319
Virginia	479
Total	$12,944,998

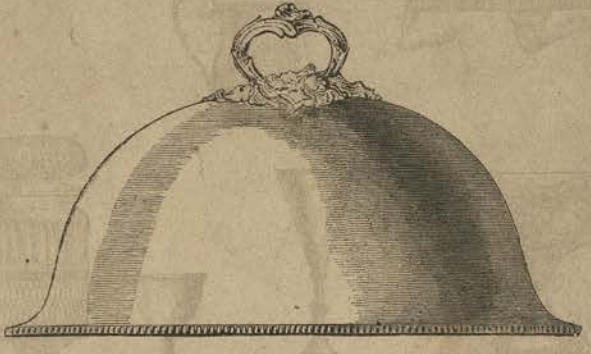
The cod fishery is the most important, if we take the number of tons employed as the guide. In 1795 there were 37,000 tons of shipping so employed. At present there are 110,000 tons employed in the business. There are several ways in which the fishing-vessels are fitted out. The leading one is for six or seven farmers with their sons to build a schooner during the winter. When the spring crops are in, they fit out the vessel with the necessary stores and go on board to make the voyage before harvest. They proceed to the "Banks," the Gulf of

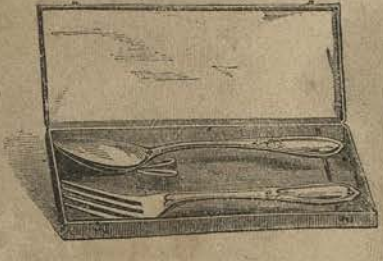
The following few engravings are a selection from among 500 different patterns of articles manufactured by Messrs. Rogers, Smith & Co., in Hartford, and show the beauty of design and elegance of finish to which this branch of American industry has attained.





HUFFMAN—KNICKERBOCKER, ALBANY.





COD FISHERY.

WHALE FISHERY.

COD FISHERY.

WHALE FISHERY.

St. Lawrence, or Labrador, and, with a good catch, get home in time to harvest. From the proceeds of the voyage they pay any outstanding claims for outfit, draw the government bounty, and divide the proceeds. After harvest they make another voyage, the catch of which is not dried, but salted down for home use, under the name of mud fish. Another plan is to charter a vessel from the owner, merchant, or other, in a company of 10 or 15, on shares; the owner finding the vessel, and nets, and salt for his share, which is usually three eighths of the whole catch. The men supply provisions, hooks, lines, and the salt for their share of five eighths of the fish. One of them is selected to navigate, for which service he gets $4 or $5 per month; otherwise he turns in to catch fish, or to work with the rest. The first spring voyage is usually made to the Banks; the second either to the Banks, the Gulf, or Labrador; and the two fall voyages also generally to the Banks.

Fish here are all caught with hooks, and are taken from the bottom. Each fisherman has a strong line, of from sixty to seventy fathoms in length, to which is attached a lead of a cylindrical shape, weighing about five pounds. This of course is the sinker. From this proceeds the "pennant," which is a cord about twice the size of the line, and is about three feet in length. To the lower end of the pennant, and attached to it by a small copper swivel, is the "craft," which is a small stout cord about two and a half feet in length, having three strips of whalebone laid around it at the middle, where it is attached to the swivel of the pennant. The whole is then serried or wound round with tarred twine. On each end of the craft is a smaller swivel, to which the gauging of the hooks is attached. The whalebone serves to keep the hooks about a foot apart, so there is little danger of their becoming entangled with each other.

The men arrange themselves on the windward side of the deck, throw over their leads, and unreel their lines, till the lead rests on the bottom. It is then drawn up so that the hook will be on the bottom with the down pitch of the vessel, and with nippers drawn on their fingers to keep the line from cutting them, they lean over the bulwarks, patiently awaiting a bite, which is known by a slight jerk on the line. They then give a sudden pull, in order to hook him, stand back and haul in the long line, hand over hand, until the fish is hauled up to the surface, when he is taken in on deck, unhooked, and thrown into a square box, which each man has fastened by his side, called a "kid." The hooks are then baited and hove over again, and the fisherman, while the line is running, picks up the fish caught, and cuts out his tongue.

Toward night, the fish are counted out from the kids, each one separately, and thrown into a large kid near the main-hatch, called the "dressing-kid." They are counted aloud as they are thrown along, and each man is required to keep his own account and report to the skipper at night, who keeps a separate account for each man on the log-book. The dressing-gang, consisting of a "throater," a "header," a "splitter," and a "salter," now commence dressing down. After passing through the hands of the first three, they assume somewhat the shape seen in market. They are then passed down between decks to the salter, who puts them up in kenches, or layers, laying the first tier on the bottom of the hold, and building up with alternate layers of salt and fish till the kench reaches the desired height. The decks are then washed down, sails taken in, and the vessel anchored for the night.

A popular, though somewhat dangerous method, called "trawling," has been employed of late years. The trawl is a long rope, with from twenty to a hundred lines depending from it, to which hooks are attached as to the common line. The rope is kept at the surface by means of keg-buoys, each one marked with the vessel's name, to prevent any dispute as to ownership. The hooks are baited and the trawl got clear and ready, and it is then taken in a dory some distance from the vessel, and set. It is generally, we believe, set at night, and hauled in the morning. The very laborious duty of hauling the trawls is performed also in dories, by two or three men in each. Occasionally, nearly every hook has done its work, but most frequently from twenty to fifty fish are the reward of their toil. Sometimes trawls are set at a distance of five or six miles from the craft, and not unfrequently do the trawl-men get astray from their vessel. In this case, they generally board some other vessel, if one is lying near, or drift about for hours until they find their own.

The herring fishery, which was formerly very abundant, has of late years fallen into

decay, for the reason that the great schools that formerly visited these shores have ceased to come, most probably because the waters resorted to by the fish to deposit their spawn have been obstructed by dams, mills, etc. For the same reason the once abundant salmon has now become scarce. The indentures of the apprentices in colonial times were said to have contained clauses that the apprentice should not be compelled to eat salmon oftener than thrice a week. Since then, through scarcity, that fish has risen to $2 a pound, at certain seasons. Streams that once afforded supplies for domestic consumption and thousands of barrels for export, now supply less than the local demand. Along the Maine waters forty years ago two hundred a day for three months in the year was not extra. A boy of 15 would take 1500 in a season with a dip-net. They probably caught them all, for very few are seen of late years. Until within twenty years salmon were plenty in the Merrimac river, but they have been driven away by turbine wheels. Of the Delaware, Susquehanna, Hudson, Connecticut, and Thames, the same story may be told of former abundance and present scarcity. As an instance of relative values, one shad was formerly thought equal to three salmon, but in certain seasons one salmon will now be worth a bushel of shad. The Aroostook river is now the source of greatest supply, but the chief quantity that comes upon the market is from the colonies. On the Pacific coast, as far south as the Columbia river, they are still abundant. In that river a navigator asserted he purchased a ton of salmon for a jack-knife. There are those who already anticipate a dinner in New York upon a Columbia river salmon, to be brought by the Pacific railroad. Some seven years ago the same table on Lake Erie presented Kennebec salmon side by side with Lake Superior salmon-trout.

The halibut fishery on George's Banks is an enterprise of recent years. It is pursued in mid-winter, and few occupations, even on the ocean, are more hazardous. This delicate fish is packed in ice, and sent by railroads, sound and sweet, to the most distant markets.

Before the construction of railroads, the whole number of halibut annually caught and brought into Cape Ann, did not exceed 2500, which were nearly all sold fresh for immediate consumption; for not having been in demand, when cured in any manner by salt, for the domestic or foreign markets, but few were prepared for that purpose. In fact, so worthless were they considered as salted fish, that the owners of the vessels employed in the fisheries generally instructed the crews to cut adrift all the halibut which were drawn up, and every year many thousands had been thus turned back to the deep with a fatal wound. But such was now the facility of transporting them *fresh*, to the New York market, that at least 16,000 were taken, and a large portion of them sent to that city by the railroads and steamboats.

The mode of taking halibut is as follows: The lines are thrown over and allowed to sink to the bottom; a heavy lead is attached, for the under current on the Banks is very strong; the fish takes the hook by suction, but the force of suction is sufficient to enable the fisherman to discover that he is "thar;" then commences the "hauling in," and the reader may believe it is no joke to haul in a line, in a rough sea, of some eighty or ninety fathoms in length, with a fish of from twenty-five to two hundred pounds' weight at the end. Sometimes the fish comes up very readily to the surface, but in most cases it is necessary to "drown" it, by drawing it some ten or twenty feet *from* the bottom, and very suddenly letting go. This last process is of course a very tedious one. The fish upon coming to the surface is seized by a "gaff," an oaken pole or stick with a strong hook attached, drawn on board the vessel, and thrown into the ice-house. Each man keeps account of the number of fish he takes, of which he receives the proceeds from one half the amount of sale.

Formerly the halibut was only caught late in the spring and during the summer and autumnal months, on the south shoals of Nantucket, along the coast of Cape Cod, in Barnstable Bay, on Cash's Ledge, and some other places, where they were most abundant at certain seasons of the year, and always in deep water, being considered, as it is termed, a *bottom* fish. But since the demand for this American turbot, as it may with propriety be called (for it much resembles that delicious fish in form and flavor), has so vastly increased, the fishermen have made explorations in search of other haunts, and, to their great astonishment, found them in immense quantities on

George's Banks, early in March; and what was still more surprising, and a fact until then entirely unknown to them, they appeared in extensive shoals on the surface of the water, like mackerel, and were taken with but three or four fathoms of line, instead of from 26 to 70, which they had been accustomed to use time out of mind in the *bottom* fishing. The Cape Ann vessels take from 200 to 500 each trip, weighing from 25 to 200 pounds.

The fish is packed and shipped mostly, if not altogether, in Boston, and thence sent to the most distant points of the South. It much surprised the epicures of New Orleans when it popped out of the ice-box in the market, not only by the strangeness of its appearance, being altogether unknown in those parts, but also by the delicacy of its rich flavor.

The growth of this fishery has been so rapid that from a small beginning it has in a few years increased to $60,000 per annum, and employs 75 nearly new and well-adapted vessels, chiefly owned at the port of Gloucester.

The mackerel fishery was one of the earliest pursued, but it did not reach much importance until the close of the last century; and it is now mostly confined to Maine and Massachusetts. There are about 30,000 tons employed in it, and the number of barrels caught annually will vary from 131,000 to 360,000 barrels. Nearly the whole of the business is carried on in Massachusetts, the other states doing but little in it. A few vessels from Maine and Connecticut fit out at Gloucester, the chief place for that industry. The merchants of Philadelphia, New York, and Boston have their agents at that place to purchase and ship for them. There are now employed in it over 1000 vessels and 10,000 men. The value is given as follows by the inspector general of Massachusetts :—

Value of vessels and outfits in Massachusetts,	$6,032,000
Value average of catch,	4,400,000

The American mackerel-catchers took of this fish one year as follows : 188,336 barrels in American waters, and 140,906 barrels in waters now claimed as the exclusive right of the Earl of Derby.

Gloucester sends out annually about four hundred schooners, ranging from 65 to 110 tons, and averaging 90 tons. Their crews for the mackerel fishery generally consist of from 10 to 14 men, according to the size of the craft; for the cod and halibut fishery, of about 8 men. The vessels are nearly all of a clipper build, fore-and-aft rig, and are valued at an average of about $4000. Most of them have all the conveniences of a mechanic's house on shore, and their cabins will generally compare, in a due proportion of course, with the cabins of any merchant-ship. It is the fisherman's pride that his craft shall compare in beauty with any other he may meet. In Gloucester the value of shipping tonnage is $1,600,000. In the months of May and June, nearly all the vessels owned in the port commence "fitting out" for the Bay of St. Lawrence, in which locality, for the past few years, mackerel abound in the greatest numbers. The "fit-out" consists in the craft being newly painted, rigging and sails renovated, anchors and cables replenished, if necessary, men shipped, and bait, salt, and provisions taken on board. She is then ready for a start. For the first few days of the passage all hands are busily employed in arranging or deciding for their fishing quarters at the rail. The best men are generally given positions near the main rigging, which is considered the most advantageous, as the fish usually rise there in greatest numbers. The men are shipped "on shares," as it is termed, *i. e.* each man is entitled to one half the fish he takes—the other half going to the vessel. After about a week's sail they arrive at their destination, which comprises the Bay of St. Lawrence, from Cape Breton island on the south and Prince Edward's island on the west to the mouth of the St. Lawrence on the north. When arrived, bait is got up and ground. The "toll-bait," as it is called, is generally menhaden, or porgies, a small bony fish, not used as an article of food. This is supplied in great quantities to each vessel. It is finely ground in a mill provided for the purpose, then mixed with water, and it is ready for use. Upon the appearance of a school of mackerel, which is indicated by a rippling of the surface of the water not unlike that of the schools of herring, the vessel is "hove to," and the "toll-bait" thrown. The fish will generally follow this bait to the side of the vessel, where all hands are at their quarters, and anxiously awaiting the first "bite." And now commences a general excitement. Each man

has his barrel by his side, and to those who have never seen the operation, the rapidity with which the fish are taken from the water is almost incredible. The men are also provided with two lines each, and upon a "strike," which means when the fish bite rapidly, these lines are in constant motion, and what seems strangest of all is the fact, that although a space of only about a foot and a half or two feet is allowed to each man for himself and his barrel, it is very seldom that the lines become entangled, even when the school being at some distance from the vessel, some 15 or 20 fathoms of length of line is required, and the fish, as soon as the hook is felt, dart hither and thither with the rapidity of lightning. After a "deck" of mackerel is obtained (which signifies a goodly number of barrels), all hands immediately prepare to put them in salt. The operations of "passing up," "splitting," and "gibbing" are gone through, and they are packed in salt in the barrels. This, with a plenty of leisure, when the fish are "slack," or do not take the hook, is the routine of the Gloucester mackerel fisherman's sea life.

The process of netting and seining is used very little, it being a much easier and safer method to take them by the hook and line.

Numbers of city and country people make trips in these fishing craft in summer season, from the fact that the business is of so healthful a nature, and is a pleasant and convenient manner of enjoying a few weeks' leisure.

These schooners make two or three trips each season, starting about the middle of May or first of June, on their first voyage, and returning in October or November from their last one. A "good trip" is considered to be about 250 to 300 barrels.

The oyster trade is a large and general one, and pervades most of the towns and cities of the Union, having spread with the facilities of transport to points that distance before deprived of the bivalvular luxury. The oysters are of a great variety of species, seemingly dependent upon the locality where they are fatted. Large numbers of oysters taken from the original beds are unfit for market until they have been *planted* or transferred to a favorable locality for them to fat. The different localities impart to them various flavors, more or less salt, and which are difficult to discriminate otherwise than by the name of the place where they were fatted, as "East Rivers," "Shrewsburys," etc. The setting, planting, and bringing them to market occupy a great number of men and no inconsiderable tonnage. They attain a marketable size in about eighteen months, and breed very rapidly. When the oyster vessel arrives in the spring from the South, it is anchored near the site of the proposed bed. The cargoes are then put into small boats that come alongside. The beds having been staked off into small squares, about 50 bushels are spread over one of the squares in such a manner that no oyster shall be upon another. By the fall, the oysters will have considerably increased in size, and greatly improved in flavor. If allowed to remain too long in sheltered waters, the oyster not long acclimated will perish with the rigor of the northern winter. The breeding time of native oysters is in April and May, from which time to July or August, they are said to be sick, or *in the milk*, and in most localities laws forbid taking them until the first of September, with a view to favor their growth. They are then caught in a net, which has on its lower edge an iron scraper. This being attached to a rope and cast over from a boat, is dragged along the bottom by a forced motion when rowed by the fishermen. The iron scraper turns up the oysters and they are retained in the net, which from time to time is drawn up to be emptied. When the water is shallow a pair of huge tongs are used to pick up a number at a time. In some places the drag or dredge is very large and heavy, and is drawn along by the vessel under sail. This process is forbidden by law in some districts, since the heavy drag crushes and destroys as many as it catches. When the season sets in, the fishermen crowd the waters where the oysters are to be had, and sell their catch in the neighboring cities. The larger dealers buy their oysters in Virginian waters, and carry them North to plant until they are fat. The value of the Virginia oyster trade has been given as follows, showing the destination of the oysters :—

	No. of bushels.	Value.
Virginia cities	1,050,000	$1,050,000
Baltimore	3,500,000	3,500,000
Philadelphia	2,500,000	2,500,000
New York	6,950,000	6,950,000
Fair Haven	2,000,000	2,000,000
Total	16,000,000	$16,000,000
Other cities, Providence, etc.	4,000,000	4,000,000
Total	20,000,000	$20,000,000

It has been estimated that the oyster trade of Baltimore is more valuable than the whole wheat trade of Maryland. The whole shores of the Chesapeake Bay are admirably adapted to their growth, and they reach maturity in one year. There are there 250 vessels engaged in the business, and their catch is 900 bushels every trip of ten days, and the annual aggregate is 4,800,000 bushels. The average value being 50 cents per bushel, the value is $2,400,000 paid by the Baltimore dealers. Some of these houses send West over the railroads 8 to 10 tons of canned oysters per day. The shells sold for manure are put at 6,000,000 bushels annually, worth two cents per bushel, or $120,000. The Long Island Sound oysters were originally from Chesapeake Bay. These oysters cost originally 25 cents, and the freight is 15 cents. The native oysters, or what are considered such, being propagated from old plants, are taken mostly for the city trade, while the transplanted oysters find their way all over the country by railroad. To preserve them they are first opened and put into kegs or cans of a capacity of 12 to 20 gallons each. These are then put into boxes and surrounded with ice. There are some 250 vessels employed in carrying oysters to New Haven. There are about 20 houses engaged in the business, the largest having branches in Buffalo, Cleveland, Hamilton and elsewhere. These firms employ a great number of boys and girls in opening the oysters. The operation is performed with incredible dispatch by the experienced hands. The instruments used are a hammer to crack the edge on a slip of iron fixed upright in the bench, and a knife. The latter is always held in the hand, while the hammer is seized, the blow given, and dropped, the knife inserted, and the oyster being seized between the knife and the thumb is pitched into the tub. The movement produces a constant click-gouge-splash, click-gouge-splash, as the tub rapidly fills with the "bivalves" previous to packing. The openers get 2 cents a quart, and they earn from $1 to $2 per day. There are 150 oysters to the gallon, and to earn $2, 100 quarts, or 3750 oysters must be opened, or during 12 hours 50 per minute!

The sea-coast by no means monopolizes good fishing. In and about the great lakes there are 35 varieties of fish, and it is said that a larger number and variety of fish ascend the Maumee river in the spring to spawn, than in any other river on the globe. These fish give rise, as a matter of course, to a large business. The number of barrels caught annually is some 42,000, which may be divided as follows: Lake Superior, 3000; Michigan, 15,000; Huron, 14,000; Erie, 3000; and 7000 barrels in Detroit river. Being sold at an average of $11 per barrel, the aggregate value is some $462,000. About one sixth of the whole quantity is trout, the remainder white fish. The mode of taking them is by "gill nets" set some ten miles from the shore. Considerable numbers are taken when, having been up Detroit river from Lake Erie to spawn, they are on their return. There are about 50 fisheries on the river. In some of the rivers that flow into the lakes, great quantities of pickerel are caught, say Fox river, Wisconsin, 1000 barrels; Saginaw river, 1500 barrels; St. Clair, 15,000 barrels; Maumee, 3000 barrels, and as much mullet, bass, etc. The annual product of the lakes and tributaries is given as follows:—

	Barrels.	Value.
Lakes	35,000	$385,000
Detroit river	7,000	77,000
Other rivers	10,000	85,000
	52,000	$547,000

One of the most remarkable fisheries is carried on in Long Island Sound and some other localities. It is the taking of what are called bony fish for manure. These fish go in immense schools, which show themselves in ripples upon the surface of the water. They are taken by nets, which may be seen by the steamboat traveller, hung upon immense reeds at the water's edge to dry. These nets are weighted with lumps of lead at the lower edge, having floats at the top, so as to keep them upright in the water. The fishers, in boats, pay out the net from one and the other, and encircle the school with it. The two ends then being carried to the shore are drawn in with great force, and an immense haul of fish results. With the bony fish, many of a better class are caught, but if the aggregate will not equal 150 cart-loads it is not thought large. These fish are spread upon the land as fertilizers. They are far better for the land than for the neighbors, who for miles round suffer odors not from "Araby the blest."

The whale fishery began at the close of the 17th century, in Nantucket, and that has been, until very recently, its chief loca-

tion. About the close of the revolutionary war, Massachusetts employed 183 vessels, of 13,820 tons, navigated by 4,059 men, and producing about $2,000,000 per annum. The business has progressed until the American seamen have nearly driven all others from the seas in that pursuit. England, to encourage her whalers, imposed a duty on foreign oils, but finding her fishers coming home more frequently without oils, while her wants were greater, and the American whalers offering to supply it, she "caved in," and took off the duty, in order to encourage her own manufacturers. Our own whalers have never had the bounty of the government like the cod fishery, to encourage them, but have on the other hand been compelled to encounter the opposition of "prairie whales," which yield their lard oil, and the multitudes of inventions of patent oils from coal and other substances, while from the growing scarcity of whales, that desert their old feeding grounds, the extreme difficulties and dangers of the business are continually increasing. Nevertheless, the hardy American seamen continue to chase them, even into the extreme arctic regions, whither the whales resort, as it was said by an old "ship's lawyer," to supply the "northern lights" with oil. In spite of all these difficulties the business has grown, probably in consequence of the peculiar manner in which it has always been conducted. The voyage being projected by the owners, the officers and crew are shipped on "lays," every man having an interest in the voyage. If the voyage is not successful he gets nothing, but if the usual success is met with, he gets a certain number of gallons proportioned to the whole, and is thus interested in the price as well. The shares of officers and men equal one third of the whole. This system has developed a spirit of enterprise and hardihood never surpassed, if it was ever equalled by any other nation. The largest seat of this business is now New Bedford, and the next in importance is New London. Fair Haven ranks next, and Nantucket has declined to the fourth position in relative importance. The annual report of the United States Secretary of State of a late date contained the following statistics of the trade, to which is added a summary of the capital and value of all the fisheries, according to the best authorities, official and experienced:—

				Value.
Vessels employed,	661	Sperm oil, bbls.	193,300	$7,571,819
Tonnage, "	203,062	Whale " "	153,850	3,392,382
Seamen, "	16,370	Whalebone, lbs.	1,538,000	1,076,600
Total value of product				$12,040,804
Value of vessels, outfit, advances to seamen, etc				$16,625,000
Supplies by masters				795,000
Money paid to officers and men for their shares				4,013,601
				$21,431,601
Add interest and wear and tear				2,004,621
Total investment				$23,436,226

The value of all the fisheries, including the whale, may be summed up as follows:—

	Vessels.	Ton'ge.	Capital.	Persons.	Value.
Whale	661	203,062	23,436,226	16,370	$12,040,804
Cod, mackerel, etc.	2,280	175,306	7,280,000	19,150	8,730,000
Oysters, etc.					25,000,000
Lake, etc.					2,375,000
Fish for manure					260,000
Total					$48,405,804

The "cod, mackerel, etc.," includes shad and other marketable fish. The item for oysters, etc., includes the turtle, clam, and other shell-fish.

ICE.

"Hast thou entered into the terrors of the snow, or hast thou seen the terrors of the hail?"—JOB.

FOR how many years, not to say centuries, was the vast icy wealth which nature confers upon northern latitudes in such profusion, and within reach of every individual, utterly unappreciated and neglected! The use of ice was indeed known to the luxurious few in remote ages. The ancient Romans learned to cool their choice wines with frozen water, and almost in every age, the "upper ten" were acquainted with its merits. Like education, and suffrage, and freedom of opinion, and toleration in religion, it however became known to and extended among the people only under our federal government. It is now no longer regarded as exclusively a luxury, but has become a necessity. Under almost all circumstances water is made palatable by it, and wines are improved by its application. The introduction of water into large cities by aqueduct, is made acceptable to citizens not only in the summer but also in the winter by the use of ice. The excuse for ardent drinks based on poor water, is removed by the possession of ice, since tepid water is rendered attractive by it. When water is thus rendered agreeable, the temptation to indulge in strong drinks is diminished. By its use, also, the supply of food is virtually enhanced, since

the surplus of districts, that might otherwise be lost, can be sent to a considerable distance to supply the wants of large cities. The surplus supplies that may thus accumulate, can be preserved for a longer time by the use of ice. The fruits of the West Indies may be preserved in the northern cities, and those of our own orchards are by the same means preserved for the markets of India, Brazil, and the West Indies. Packet ships no longer carry live fowls and pigs, since a small ice-house may be packed with fresh provisions for the voyage. The markets of all large cities are provided with hundreds of ice-chests, in which fresh provisions are preserved free from taint. Fishermen have become greatly dependent upon ice, which enables them to keep a large and full supply of fish in every variety, and almost every family has its refrigerator or ice-box, which, regularly supplied, is the recipient for butter, milk, and other food. Thus families are as readily furnished with ice as with milk. To country houses and substantial farmers, ice-houses have become a necessity for the same general reasons.

Not the least important use of ice is its medical applications. It is a reliable tonic and of the safest. In cases of fever it has become of general use. In India the first prescription of a physician is ice, and sometimes it is the only one, and the ice is always American! If India sends us her opium, she gets as valuable a return in ice. That article is also a styptic, and has many important medical applications. All these benefits and many more were annually provided for humanity in the frosts of winter and in the congealing of water, but were disregarded until an enterprising Yankee adopted the notion of harvesting that crop. Massachusetts to be sure has but two crops, and it required two centuries to discover them. For more than 200 years the snow fell upon and melted from her granite hills, before speculation, putting its hand upon them, sent them along the coast by schooner loads as material for palaces. For more than 200 successive winters the clear and sparkling ice showed itself upon her ponds, and vanished under the vernal sun, before enterprise detected in its preservation the means of increasing human enjoyment. Those frozen lakes were each winter covered with gold, but, like that of California, it was long undiscovered. It will, however, never run out, since, without ploughing or sowing, nature sends the annual crop, which like the manna has only to be gathered, and the market for it is ever increasing.

There were many farmers possessed of ice-houses in the middle states, at a date as far back as the formation of the government. But the idea of making a trade of it seems to have occurred first to Frederick Tudor, Esq., of Boston, in 1805. He shipped a cargo in that year from Boston to Martinique. The ice was cut with axes, and carted in wagons to Gray's wharf, Charlestown, where it was shipped. The voyage proved a total loss, as did several succeeding ones, until the war put an end to trade. Mr. Tudor resumed it at the peace, and persevered in face of continued losses, until 1823, when he extended it to the southern states, and the West Indies, and it began to pay. As long as it was a losing business he had it all to himself; as soon as his perseverance had mastered the business and made an art of it, he began to have competitors. Up to 1832, however, he was alone in it, and in that year extended his shipments to Calcutta, Madras, and Bombay, and also to Brazil. These were the first ice shipments ever made to those countries, and they have ever since been good customers. Since 1832, a number of firms have engaged in it. In that year the shipment was 4,352 tons, cut from Fresh Pond. In 1854, it had grown to 154,540 tons.

The use of ice extended itself in all the cities of New England, and in Boston became very general. The quantity there used, is about 70,000 tons per annum, against about 27,000 tons in 1847. The ice is cut mostly from Fresh and Spy Ponds; at the former the houses are capable of containing about 87,000 tons. The price of ice for shipping, is usually $2 per ton, and rises from that to $6 after mid-winter. The article is served to families at the rate of $5 for the season, May to October, for nine lbs. per day; 15 lbs. are served for $8, and 24 lbs. for $12. When large quantities are served, the price is 17 cts. per hundred, and $3 per ton to hotels when 500 lbs. per day are taken. In New York the quantity used is nearly 285,000 tons. This is supplied in the proportions of 120,000 tons from Rockland Lake; 30,000 from Highland Lake; New Rochelle, 10,000; Athens, 15,000; Rhinebeck, 18,000; Kingston Creek, 60,000; Catskill, 20,000; Barrytown, 12,000. Of this quantity, 113,000 tons are stored by the Knicker-

bocker Co., and the remainder by four firms. The cities of Newburg, Poughkeepsie, Hudson, Albany, Troy, lay up from 5000 to 20,000 tons each. In central and western New York the use of ice is large. It commenced at Syracuse in 1844 for the supply of a saloon, and it was gradually extended to butchers and families, and the quantity there used is about 10,000 tons, taken mostly from Onondaga Lake, from which it is drawn two or three miles to be stowed in an ice-house. The other cities of western New York have followed the example, and the average price is 20 cts. per hundred. Cincinnati used to draw its supply of ice from its own vicinity; but the railroad facilities permit of drawing it cheaper and better from the lakes. Chicago is well supplied from the same source. In the neighborhood of Peru, Illinois, a large quantity is cut for the supply of the lower Mississippi. It is cut in the winter and packed in flat-boats which are allowed to freeze up in the Illinois river; there is therefore no other ice-house needed. As soon as the river breaks up in the spring, the boats float down stream and supply the markets below. In Philadelphia, Baltimore, and Washington, ice is more important than in the cities of the North. When the weather sets in cold in the early part of the winter, they cut ice in the neighborhood, but the best supplies are from Boston or from more northern lakes. The Atlantic and Gulf cities of the South get most of their ice from Boston, which sends them about 110,000 tons per annum, and further quantities to Havana and the West Indies. Rio Janeiro, Callao, and Peru, Charleston, Mobile, and New Orleans, are large customers of Boston in the article of ice. In New Orleans, substantial brick ice-houses have been erected at a cost of $200,000, and similar arrangements have been made in Mobile for its distribution. The quantity exported to Europe is large, and England takes about 1,000 tons of American ice.

It follows as a matter of course, that where this object of industry and enterprise is formed by nature, the means of conducting the trade will gather around it. Hence the land in the immediate neighborhood of fresh-water lakes at the North rises in value, and good wages come to be earned in the winter by men who at the dull season would otherwise not be employed. The question soon presented itself to those who were engaged upon cutting ice on the same pond as to their comparative rights. This was settled at Fresh Pond by a committee, who decided that each owner should hold the same proportion of the contiguous surface of the pond as the length of his shore line is to the whole border.

The time for cutting is December and January. The "experts" can in the middle of January estimate the value of the crop. When the ice is sufficiently thick to cut, say from nine to twenty inches, the former for home use and the latter for exportation, if there should be snow upon the surface, it is removed by wooden scrapers drawn by horses. There is a layer of what is called "snow ice," that is not fit for market; this must be removed, and for this purpose an iron scraper with a cutting-edged steel is drawn over it by a horse. A man rides upon the scraper, which in its progress cuts several inches of the snow ice from the surface of the clear and glittering article that is to go to market. When this is completed, the field of ice is marked off into squares of five feet each. The marker is drawn by a horse, and is guided by handles like a plough. In the tracks of these marks and cross marks follows the cutter. This is a remarkable invention, which has reduced the cost of cutting ice in the neighborhood of Boston alone, some $15,000 per annum. Acres of ice are thus cut into square pieces, which are then floated off through canals, and impelled by long poles, to the sides of the pond, where inclined planes lead up to the ice-houses; up this inclined plane each piece is dragged with great celerity by a powerful steam engine. In the house it is directed by hand down other planes to be packed away by the requisite number of men. By the aid of steam ten tons of ice may be cut and housed in a minute. With a full power, it is not uncommon to stow 600 tons an hour. Sometimes there are several parties on the pond, each vieing with the other in the rapidity of their operations.

Most of the ice-houses that we have seen are built of wood. Sometimes they are found of brick. They are very high and broad, and are usually from 100 to 200 feet in length. Fresh Pond, Cambridge, Mass., has its shores almost covered with some fifty of these ice-houses. They present a singular appearance, neither looking like barns nor houses; and one unacquainted with the ice business would be almost certain to ask, on

seeing them for the first time, "What are they?" The construction of these houses, in which ice is to be stored until sold, must be regulated by the climate—the amount to be stored—the material nearest at hand—and the facility of reaching the shore—the object being to have a cool spot, where the influence of the sun and a warm atmosphere shall be least felt. Added to this, the mass of ice must be preserved as much as possible from wasting, by being surrounded by sawdust, tan, shavings, rice-hulls, charcoal, or leaves, which must be used in the ice-house, or aboard ship, according to circumstances.

Private ice-houses are constructed in different ways. They were formerly merely cellars; they are now in the most approved methods erected above ground, with a drain under the mass of ice. The opening is generally to the north, and the ice is the better preserved for a double roof, which acts as a non-conductor. The waste of ice is different under different circumstances; shipping ice should not waste more than 40 per cent.; and when shipped on an India voyage of 16,000 miles, twice crossing the equator, and occupying some months, if one half the cargo is delivered it is considered a successful voyage. The cost of the ice delivered is of course affected by this element of wastage. In Boston, it is $2 per ton. In Calcutta, 2½ cts. per lb., or $56½ per ton. The use of ice in India, as we have said, is medicinal as well as luxurious, and the demand is generally quick. There is hardly a nook or corner of the civilized world where ice has not become an essential if not a common article of trade. While we admire the persevering energy of the enterprising Yankee, who started the trade amid every discouragement, and carried it to a successful issue, which gives employment to thousands of men, and freights to hundreds of ships and boats, and confers an inestimable blessing upon, we might say, the human race in all warm climates, we cannot but consider how vast a harvest perishes yearly. Hundreds of lakes and rivers in the northern section of the country present their annual harvest of pure ice, and yet they pass away ungathered. How many millions, in all parts of the world, even within the limits of the United States, pine during the long summer months of each year for this tonic! The time is coming when every farmer will gather this crop as regularly as his potatoes. When Daniel Webster took his farm at Marshfield, his ice-house cost $100, and it was filled annually at an expense of $25. In that he preserved his fresh meat and fish, and prevented his butter from "running away." Sometimes farmers live in sight of fine ponds that would give a plentiful crop, that might be harvested and sent by railroad to good markets, without ever bestowing a thought upon the matter. To get $2 or $5 for hauling, would pay their otherwise idle teams at that season well. We may close this notice by an extract from an oration of the Hon. Edward Everett, as follows:—

"When I had the honor to represent the country at London, I was a little struck one day, at the royal drawing-room, to see the President of the Board of Control (the board charged with the supervision of the government of India) approaching me with a stranger, at that time much talked of in London—the Babu Dwarkananth Tagore. This person, who is now living, was a Hindoo of great wealth, liberality, and intelligence. He was dressed with Oriental magnificence—he had on his head, by way of turban, a rich Cashmere shawl, held together by a large diamond broach; another Cashmere around his body; his countenance and manners were those of a highly intelligent and remarkable person, as he was. After the ceremony of introduction was over, he said he wished to make his acknowledgments to me, as the American minister, for the benefits which my countrymen had conferred on his countrymen. I did not at first know what he referred to; I thought he might have in view the mission schools, knowing, as I did, that he himself had done a great deal for education. He immediately said that he referred to the cargoes of ice sent from America to India, conducing not only to comfort, but health; adding that numerous lives were saved every year by applying lumps of American ice to the head of the patient in cases of high fever."

PINS.

THE manufacture of pins has reached a great development in the United States, where the most important invention in the art of making them, that of "solid heads," originated. So simple an article as pins formerly required a great manipulation in their production, but are now, like most articles that have been the objects of American

ingenuity, produced in great perfection and abundance by machines. Up to the war of 1812, pins, like almost every other article of manufacture, were imported, and, as a consequence, became very scarce when communication was interrupted, and the price rose in 1813 to $1 per paper, of a quality much worse than are now purchased for 6¼ cts. per paper. These high war prices prompted the manufacture, and some Englishmen commenced the business at the old State Prison, at what was called Greenwich village, now a part of New York city. The labor of the convicts was employed in the business. The return of peace bringing a deluge of cheap pins from abroad, put an end to that enterprise. The tools used in the manufacture at the prison fell into the hands of a Mr. Turman, who in 1820 undertook to employ the pauper labor of the Bellevue Almshouse in the manufacture, which was, however, unsuccessful. "Pauper labor" here, it seems, could not compete with pauper labor abroad. A machine had been invented during the war, for making pins, in Boston, but it did not work successfully. The old pins had the heads put on them; but Mr. L. W. Wright, of Massachusetts, invented a machine for making solid-head pins. He carried this to England and operated it there, and the first "solid-head" pins were sold in the market in 1833. In 1832 a pin machine was patented in the United States by John J. Howe. The machine was designed to make pins similar to the English diamond pins, the heads being formed of a coil of small wire fastened upon the shank by a pressure between dies. In December, 1835, the Howe Manufacturing Company was formed in New York for the purpose of manufacturing with this machine. The company moved to Birmingham, Connecticut, where it continues operations with a new patent for manufacturing solid-head pins, got out by Mr. Howe in 1840. In 1838 another company was started at Poughkeepsie, notwithstanding that by an extraordinary oversight pins were under the tariff admitted free of duty, while the wire of which they were made paid 20 to 25 per cent. duty. In 1846 there was much excitement in respect to the pin manufacture, and many machines were invented; few of them, however, succeeded in doing good work. Most of the attempts to manufacture failed. The Poughkeepsie Company was, however, sold to the American Pin Company, Waterbury, Connecticut. About the year 1850 the copper from Lake Superior began to be used for the wire, giving an impetus to the business, and 250 tons were used per annum. Great improvements were made by self-acting machinery superseding a process that formerly required six or seven hands. The old method of sheeting pins, or sticking them on paper, was a tedious process; a good hand could stick five or six dozen papers in a day. By the improved machinery now in use, a hand will stick from 75 to 125 dozen a day, and do the work in far greater perfection. There are three patents in force for improvements in the machines in use for this operation, viz., those of S. Slocum, De Gras Fowler, and J. J. Howe. The present price of American solid-headed pins is only about two thirds of the lowest price at which imported pins of the same weight were ever afforded before the manufacturing was introduced, and for service they are undoubtedly better than the article of which they have taken the place. The American improvements in both the pin-making and the pin-sticking machinery have been for several years in operation in England and some other parts of Europe.

One firm in Waterbury, Connecticut, have in operation an improved machine for the manufacturing of pins which turns out *two barrels* per day. A barrel contains 4,000,000 pins, consequently the product of that little manufactory is 8,000,000 per day, or 48,000,000 per week, and 2,496,000,000 per annum. Well may it be asked "where all the pins go to?" The machine is perfect and simple in its operation. The wire is run into it from a reel, cut off the proper length, pointed, headed, and made a finished pin before it comes out again. From this machine they fall into the hopper of the sticking machine, in which they are arranged, stuck upon papers, and come out perfect, ready for packing for market. This last machine, tended by one girl, does the work of 30 persons by the old process. That is better than pauper labor. There are four other machines in the United States. These operating at the same rate, will make 312 pins per annum for every soul in the Union. There should be a large surplus for export to other countries, and at a profitable rate, after paying freight and charges, since no European machines can compete with this little contrivance.

REFINED SUGAR.

The people of the United States are famous for having a "sweet tooth," and if the story about "pork and molasses" is not quite accurate, it is nevertheless true that a "little sweetening don't go far" in a family, or, to use a New York phrase, *into* a family. The figures show that consumption in the United States is far ahead of any European countries, but is less than that of Cuba, where it is enormous, being to a great extent used in preserves that are largely eaten as well as exported. In the year 1859, the quantity of foreign sugar taken for consumption in the United States was 239,034 tons. The crop of Texas, Louisiana, and Florida was 192,150 tons, making together 431,184 tons of cane sugar. The quantity of sugar made from molasses was 12,053 tons. The crop of maple sugar was 27,000 tons, exclusive of California and Oregon. The result is a total of 470,237 tons, or 1,058,033,000 lbs. Allowing the population of that year to have been 30,000,000, the result is 35½ lbs. per head per annum. In Great Britain the consumption is 28½ lbs. per head, in France 9 lbs. per head, and in Germany still less. In those countries, however, the sugar is used almost exclusively in its refined shape, but very sparingly. During the long wars of Napoleon it was difficult to come by, and the manufacture of beet-root sugar, now so important, grew out of the necessities of that period. A generation grew up in the economical use of sugar, and even to this day in the rural districts, and among some of the old fogies of the cities, no other sugar is used than a piece of the sugar-baker's candy held in the mouth while the unsweetened liquid is drank. The story is told that this piece was formerly, in the times of privation during the war, suspended by a string from the ceiling over the table, and being taken in the mouth by one *convive* when drinking, was allowed to swing to that of her whose turn succeeded. The German idiomatic phrase of "*pass auf*" or "look out" for the next was said to have thus originated. In our own colonies the refiner was not by any means considered a necessary go-between of the cane and the consumer, who went directly to the fountain-head and used the molasses, or "long sugar," not only for his coffee, but to compound his new rum or "white-face" into "black-strap," with which he washed down his pumpkin pie, also sweetened with molasses; and few edibles escaped that sweetening, from a spoonful of brimstone in the spring to a mince pie at Christmas. Refined crept in, and with the use of this article various grades of pure sugars made their appearance. When the plants or canes are crushed in a mill, the juice flows abundantly through a strainer into the clarifier; where, mixed with alkali, which assists the operation, it is raised to a certain heat. It then passes through evaporating coppers, and the scum that arises in the process is removed. In the last copper it is boiled until it will granulate in the boiler. Here it soon ceases to be a liquid, and being placed in hogsheads with holes in their bottoms, the molasses drains out into a cistern below. When quite cured in this manner it is shipped as "brown" or "muscovado" sugar.

The next grade of sugar is "clayed;" when the sugar is properly boiled, it is poured into conical pots, apex down, with a hole in each. When the molasses has drained off, a stratum of moistened clay is spread over the surface, the moisture of which percolating through the mass contributes powerfully to its purification.

"Refined" sugar may be prepared by taking either the clayed or muscovado, redissolving it in water, and after boiling it with some purifying substance, as blood, or other articles, pour it into the conical pots again with the clay application.

The solutions of brown or clayed sugar, boiled until they become thick, and then removed into a hot room, form into crystals upon strings placed across the vessels, and become sugar-candy.

The use of molasses and brown sugar, as we have seen, is by far the most important in the United States. In the year 1857, when the Louisiana sugar crop failed, the importation of these articles reached nearly $57,000,000, and the import contributed principally to the panic of that year. Gradually the use of refined sugar has extended, and in 1850 the federal census reported 23 refineries, having a capital of $2,669,000, and using $7,662,685 worth of raw sugar, perhaps 70,000,000 lbs., and producing a value of $9,898,800. Since that period the business has greatly extended itself. In that year there were two in New York city, Woolsey's and Stuart's. These rapidly increased to fifteen, who together refined 200,000,000 lbs of sugar, or about half what was produced in the whole United States. The introduction

of machinery moved by steam almost revolutionized the business of refining. An important improvement that was made in substituting aluminous finings for bullock's blood, which was always productive of injurious consequences, greatly increased the production and raised the quality of sugar. The raw sugar of the Spanish West Indies and Brazil comes mostly in cases and boxes; that of New Orleans and the English islands in hogsheads; South America generally, Manilla, and the Mauritius send it in bags. When the refiner gets possession of any of these, he empties into a pan with a perforated bottom; through these perforations comes a current of steam which dissolves the sugar. Chemical application then bleaches the sugar or takes all its color from it. It then passes into the vacuum pans to be boiled by steam. The sugar in this process becomes so concentrated that it is held in solution only by the high temperature. The moment it begins to cool, a rapid crystallization takes place, producing the fine grain seen in loaf sugar. When the syrup has boiled sufficiently, it is poured into moulds which are prepared in the loaf form, for the purpose of facilitating the separation of the sugar. The liquor that runs from these moulds is subjected to a new boiling, when it yields lower grades of sugar. The syrup that exudes from this second process is sold as molasses, and the proportion of this is about 20 per cent. of the original quantity.

The art of refining has been carried to greater perfection in this country than in Europe, and so manifestly that no imported article can equal the fine granulated sugars of the domestic manufacturer. The business has spread with the demand for the improved sugars. The increase of the manufacture has also been aided by the federal government, which allows a drawback upon refined sugar exported equal to the duty on the equivalent raw sugar imported. The export of refined sugar was last year 3,141,835 lbs., worth $368,000. The manufacture of sugar into candy and confectionery is carried on to the value of $5,000,000 per annum. Some years since, the bounty or drawback upon refined sugar amounted to more than the duty on the raw article, and was therefore equivalent to an additional bounty on the manufacture. It was not surprising that the business should spread under such circumstances, the more so that modern inventions contributed largely to its improvement. The capital invested in the business is some millions. The value refined in New York is now some $17,000,000 per annum, and the refiners of Philadelphia have a capacity of some $10,000,000. There are a number of refineries in the eastern states, and some in Baltimore, St. Louis, Cincinnati, and New Orleans. These are sufficient to meet the demand for consumption, and the importation has become unimportant. One of the largest refineries is Stuart's, the annual sales of which are over $3,500,000. The concern works up over 45,000,000 lbs. of sugar per annum, employing some 321 men. The quantity of coal used is from 7,000 to 8,000 tons per annum, and the value of the bone charcoal used in the finery process is $30,000. A week's operation requires a supply of 763 hogsheads of sugar, or at 1,110 lbs. each, 840,000 lbs. This, for the working time of six days, gives one hogshead for every 11¼ minutes. The sugar is by steam power hoisted to the top of the building, where it is emptied into an immense copper, when the steam soon converts it into the fluid state. In its descent through the building by pipes and tanks it undergoes the various purifications to which it is subjected. The flow of the vast quantity is like an abundant supply of water, and the rich product finds its way on the ground floor into barrels ready to meet the extensive demand that the high quality occasions. One large refinery was erected and furnished at an expense of $875,000. The growing luxury and refinement of the country is making refined sugar more of a necessity than formerly, and it is to be remarked that the use of refined sugar increases the demand for the raw material nearly 50 per cent., since 1½ lbs. of cane sugar are required to make 1 lb. of white. The concentrated sugar undoubtedly contains greater strength, but the quantity used is not curtailed on that account; on the other hand, it seems to increase, since the custom of "putting down" preserves in families extends, and the purest sugar is required to attain that clear appearance of the preserved fruit on which housewives so much pride themselves. The use of sugar for this purpose fluctuates with the season for fruits. In those years in which peaches, for instance, are abundant, a large number are preserved. A basket of peaches in New York will weigh 50 lbs., and the fruit with the stones taken out, 25 lbs., requiring as much sugar. Some years the peaches are worth $5, of the preserving qual-

ity, which is a clear white, and in other years, 50 cents. In the latter case, the sugar is worth four times as much as the fruit; in the former, one half as much, hence a great fluctuation in the use of sugar, which must be of the best refined. This demand takes place for all kinds of small fruits as well as peaches, and it grows in the double ratio of numbers and wealth. Strawberries may be preserved with granulated, but would hardly be palatable done up in "long" sugar.

SILK.

The culture and manufacture of silk are among the oldest industries of the colonies, and many efforts on the part of Congress and of enterprising men have been made to promote them, but the industry has not thriven in any degree to be compared with some of those that have grown steadily under the intelligent perseverance of unobtrusive individuals. No branch of industry is ever planted, promoted, or perfected by means of government operations alone. It must grow, if at all, out of the spontaneous promptings of individual genius, and live upon the necessities that give rise to it or the wants it of itself creates, to be healthily prosperous. Hence all the efforts that have been made to encourage the silk culture and manufacture have proved abortive, while individuals not encouraged have prosecuted branches of the trade not contemplated, with success. The southern colonies were early silk producers. So important had it become in 1753, that at a meeting of the imperial Board of Trade, Oct. 26, of that year, "the state of the colony of Georgia was taken into consideration, at a Board of Trade and Plantations, and it appeared that the colony produced upward of £17,000 [75,000 dollars] worth of *raw silk*, since January 1752, besides what is not yet come to the notice of the board." The other colonies of the South were also well engaged in it. Virginia in particular was largely interested in that industry. The culture of cotton and tobacco, however, in the early years of the Union, were so profitable as to absorb all other culture; and silk nearly disappeared, although numbers of farmers preserved their mulberry groves, and continue to make small quantities of raw silk. The state of Connecticut seems to have made the most decided efforts in that direction. The *New London Gazette* of 1768 informs us that William Hanks of Mansfield, had "raised silk enough for three women's gowns." The gowns of "three women" at the present day would involve a formidable amount of silk, but we are to presume he meant three "dresses" simply. The term gown, like "vandyke," seems to have become somewhat obsolete. Mr. William Hanks also advertised in the *Gazette*, 3,000 mulberry trees, three years old, and of one inch diameter. The best time to set them out, he says, is at the new moon of April. They were to be sold cheap, in order to promote the culture of silk. Sundry gentlemen in Windham had large mulberry orchards, intended to supply a silk factory erected at Lebanon. While all manufactures were in so depressed a state and struggling for life under the disability of deficient capital, it was hardly to be expected that so hazardous an undertaking as silk manufacture could make much progress. When, however, the high tariff policy after the war gave the spur to manufacturing of all kinds, that of silk was revived, mostly in Connecticut and Pennsylvania. This had so progressed that in five small towns of the first-mentioned state, there were raised in 1829, 2½ tons of raw silk, valued at $21,188. In Washington, Pennsylvania, sewing silk was successfully produced, and some garments were made by individuals who performed the whole work, from the management of the worms to the weaving of the fabric. The town of Mansfield, Connecticut, was in that year the great seat of that industry. The population was 2,500, and produced as many pounds of silk. This silk was converted into the most beautiful sewing silk and some other manufactures by the skill and industry of that ingenious people. Thus prepared, the silk was at that time worth $8 per lb. This industry was carried on without interrupting the ordinary occupations of the people, and also employed the young and old not suited to the labors of the field. The mulberry trees are ornamental as shade trees, and do not impoverish the soil as much as fruit; and they will flourish in almost all latitudes, or wherever the apple will grow; and wherever they are present the silk-worm may be reared.

The feeding of the worms commences with the first opening of the mulberry leaf,

and continues for the period of 32 days, when the worm commences its spinning and ceases to eat. The leaves are gathered for the worms, and this gathering is the appropriate work of young children. Having wound itself in its cocoon, it requires nursing and watching, that the young may not eat its way out and by so doing destroy the silk. The cocoons being placed in warm water to soften the natural gum upon the silk, the winding is begun by women, one of whom can make 16 lbs. of raw silk in the season of six weeks.

The excellence of the silk depends upon the properties of the mulberry leaf, and these are considerably diversified. The white mulberry is decidedly the best, and of this there are several varieties, each of which depends in some degree upon locality. The kind to be cultivated and the mode of proceeding are to be learned from experience, which was very limited in the United States in 1829, when the attention of Congress was called to the silk culture by the petition of G. B. Clark, of the city of New York, for a grant of 262 acres of land owned by the United States, at Greenbush, New York, and used for military purposes, to aid him in rearing mulberry trees. The grant was made in the shape of a lease, on the condition that 100,000 mulberry trees should be planted, and that he should procure a sufficient number of worms to consume all the foliage that can be gathered from the trees. The public objects to be gained were to ascertain the best kinds to be cultivated, and to obtain a quantity of that description for distribution. No very great results flowed from this movement. The culture never amounted to much, but the tax, 15 per cent., imposed upon imported raw silk in order to encourage the culture, was a great drawback upon the manufacture. Nevertheless, the excitement in relation to the mulberry trees progressed, and in the year 1831, the project of rearing silk-worms was renewed in various parts of the Union, with great vigor; and the subject was deemed to be of so much importance that it not only attracted the attention of Congress, but afterward received encouragement from the legislatures of several states, by bounties offered for all the raw silk produced within their limits for certain periods of time. The business soon began to be prosecuted with extreme ardor, and continued several years, resulting in the establishment of extensive nurseries of mulberry trees, but it ended with the downfall of the famous "Morus Multicaulis Speculation," in 1839. The rates of the mulberry cuttings were at 2 cents each in 1838. In that year, in the neighborhood of Hartford, Connecticut, many thousand trees were sold at 20 to 50 cents each. The trees were sent all over the country, and it was stated that the growth per acre gave from three to five thousand dollars. The demand for trees was from those who undertook, in all sections of the country, to plant mulberry groves for the supply of silk factories that were to be started. The sales of trees were often made on the ground, standing, at the rate of 12½ cents per foot, those "trees" not 12 inches high being rejected. That speculation is yet alive in the public mind as a monument of the folly which at times overtakes a community, even to its own destruction. It was second only to the famous tulip mania of Holland, or the South Sea bubble of England, or the Mississippi scheme of France. The mulberry buds sold at fabulous prices, and passed rapidly from hand to hand of the speculators, multiplying from the nurseries to meet the speculative demand, which suddenly ceased when the test of practicability was applied. The real evil, however, which the mania inflicted, was that the means taken to stimulate a doubtful culture retarded the manufacture of sewing silk and goods, because the high price of the raw material so occasioned made competition with the foreign article impossible. In 1836, the state of Massachusetts paid $71 bounty on silk made in that year. This bounty rose to $2,111 in 1841. All the means used had raised the quantity of silk made in the United States in 1840, to 61,552 lbs., worth about $250,000. In 1844, the quantity was stated in the report of the commissioners of the United States census at 396,790 pounds, worth $1,400,000. In 1850, however, the quantity had fallen to 14,763 lbs., showing an immense decline, which has been ascribed to inherent difficulties of the climate. Nature seems to have put a veto on it at the North, and at the South other cultures have proved more profitable. The effort to produce the silk failed, and caused the failure of, or at least retarded, the silk manufacture, which has grown in England in some degree to rival France, where the silk is raised, by means of entire freedom from tax on the raw ar-

ticle. Of late, some further progress has been made in the manufacture.

In the year 1769, on the recommendation of Dr. Franklin through the American Philosophical Society, a filature of raw silk was established in Philadelphia, by private subscription, and placed under the direction of an intelligent and skilful Frenchman, who, it is said, produced samples of reeled silk not inferior in quality to the best from France and Italy. In 1771, the managers purchased 2,300 pounds of cocoons, all the product of Pennsylvania, New Jersey, and Delaware. The enterprise was interrupted by the Revolution. A similar enterprise was again attempted in 1830, under the supervision of M. J. D. Hornerque, and cocoons were brought in abundance to the establishment from various parts of the country, and so continued for some time afterward; but for want of capital, the undertaking failed. About the same time, however, other undertakings were begun in various parts of the country, and some of these have attained a high degree of success. In 1841, the convicts in Auburn prison, New York, were employed in the manufacture of silk for a time, with much success. In the first year a value of $12,762 was produced of sewing silk, pronounced superior to the imported article. The domestic supply of the raw article running short, through defects of climate, that manufacture began more severely to feel the weight of the duty of 15 per cent. *ad valorem* on raw silk, and of 10 to 30 per cent. on dyestuffs. These duties were a direct discrimination in favor of the English manufacturers, who obtained those materials free of charge. Nevertheless these manufactures here and there had taken root, in spite of this attempt to force the culture of the silk by means that tended to destroy the market for it. Many manufactories of ribbons grew in favor, and produced goods with a texture, finish, brilliancy of color, and general adaptability for an extended consumption that gave them advantage over the imported goods. In sewing silk, particularly, the American manufacturer has excelled. The American article is in every respect equal in color and finish to the imported, and superior in the spinning and "fixing the cord" (the great desideratum in this branch of manufacture) to the Neapolitan article.

The following figures show the rapid progress of the manufacture now that the raw silk is free of duty. From 1830 to 1850, the import of the raw silk increased 300 per cent. The manufacture had, meantime, gathered strength, and in the last ten years it has risen to over $1,540,000 per annum, while the import of sewing silk is nearly extinguished. The largest portion of the silk is derived directly from China.

IMPORT OF RAW SILK.

	Raw. 1830.	Raw. 1850.	Sewing. 1850.	Raw. 1860.	Sewing. 1860.
Hanse Towns.	..	$7,635	$1,873	$6,716	$4,733
Holland.....	..	..	16	..	..
Dutch E. I. ..	..	2,073	297	..	..
Engl'd & Scot.	17,985	164,695	112,258	600,901	72,057
B. N. A. Cols.	..	..	43	..	..
B. East Indies	..	18,226	..	..	..
France	3,240	10,606	101,867	15,470	17,699
Italy	8,153	..	187,068	4,604	..
Sicily	..	..	76,782	..	238
Turkey.....	..	2,623	..	..	..
China.....	89,696	198,619	9,288	915,504	7,185
	$119,074	$386,281	$489,487	$1,542,195	$111,912

FIRE-PROOF SAFES AND SAFE-LOCKS.

But a very few years have passed, since it was a matter of necessity for individuals to keep their valuables in their own houses, and to defend them from the attacks of burglars and the risks of fire, as they best could. For these purposes strong boxes were in requisition. In modern times, paper promises have been substituted for the hard currency of former times, and banks become the depositories for that money, thus relieving individuals of the risk of keeping coin in their houses, to attract thieves. The banks are also depositories for plate and jewelry, and insurance companies guarantee from loss by fire. Under these circumstances, it was hardly to be anticipated that a demand for strong boxes should arise, when the use of them was apparently on the decline. Singularly enough, however, the art of making strong boxes has only been developed in the present century. It is to be considered, however, that with the progress of the credit system in the last 150 years, and the extension of commerce, paper securities and account-books of all kinds have multiplied, causing a greater demand than ever for iron chests. The manufacture of these, and of the locks to secure them, has taken great dimensions.

It is obvious that, in the construction of a chest, designed to be not only burglar but fire-proof, iron, as a material, would naturally suggest itself. Neverthe-

less, oak seems formerly to have been a favorite material, probably from the facility of working and ornamenting. An example of this kind of coffer is afforded in the chest in which the crown jewels of Scotland were deposited in 1707. The chest, beautifully ornamented, was secured with iron bands, hasps, and staples. There were three locks, which then, no doubt, afforded security, but each of them could be opened in five minutes with a bit of crooked wire in our day. At the close of the last century there began to be made the iron chests, known as "foreign coffers." These were constructed of sheet iron, strongly riveted to hoop iron, crossed at right angles on the outside. A lock throwing eight bolts inside, and two bars and staples for padlocks outside, were employed to secure the lid. Over the door lock was a cap beautifully pierced and chased, and a secretly operated escutcheon concealed the key-hole. These were formidable to look at, and no doubt answered their purpose all the better, that the science of lock-picking was then not so advanced as in the present day.

About the beginning of the present century, cast-iron chests began to be made for common purposes, and the manufacture flourished to a considerable extent. The idea of introducing non-conducting substances as a protection against fire, occurred but some years later. The favorite substance for this purpose is gypsum or plaster of Paris. This material was first used in Paris for the construction of fire-proof houses. The practice for more than fifty years had there been to erect hollow walls with spaces between them varying from five to nine inches in width. Plaster of Paris, mixed with water to a proper consistency, was poured into these spaces, where it set and became hard. After the beams and rafters were fixed in their places, boards were nailed to them, and the same material was spread thereon. The lower floors of the building were of plaster, over which tiles were laid. The same material was applied to fire-safes in Paris, and these were, to some extent, imported into New York about the year 1820. The first portable fire-proof chests introduced for sale in New York, were imported from France, by the late Joseph Boucheaud, Esq., about 1820, and no doubt many of our old merchants and bankers remember them, as many were sold for use in counting-houses and bank vaults. They were constructed of wood and iron; the foundation was a box of hard, close-grained wood, covered on the outside with plate iron, over which were hoops or bands of iron, about two inches wide, crossing each other at right angles, so forming squares on all sides of the chest. Holes were made in the bands and plates, through which well-made wrought-iron nails or spikes, having "*hollow*," half-spherical heads, were driven into and through the wooden box, and then "*clinched*." The inside of the chest was then lined with a covering of sheet iron. These chests had a well-finished but very large lock, having from six to eight bolts, operated by one turn of the key.

The first actual application of plaster of Paris to safes in this country seems to have been by James Conner, the type-founder, of New York. His business made him acquainted with the non-conducting qualities of plaster of Paris, and he applied it to an iron chest in his office, which chest has been in use ever since. Soon after, Jesse Delano, of New York, began making chests of the Paris pattern, substituting solid cast-iron heads, to secure the bands. In 1826, he patented an improvement, which consisted in coating the wooden foundation with a composition of equal parts, clay and lime, plumbago and mica, or saturating the wood in a solution of potash lye and alum, to render it incombustible. These were generally used in the country, and as a curious instance of the *fire-proof* qualities of these safes, we may state that one stood many years near the stove, in the counting-house of Lyman Stockbridge, of Hartford, until its fire-proof qualities seem to have been exhausted, since it spontaneously took fire and burnt up about three years since, without doing other injury on the premises. In this case, it would seem the fire-proof quality was inverted—viz., that the fire could not get *out*, instead of failing to get in. After Mr. Delano, C. J. Gayler began the safe manufacture, and in 1833 he patented his "double" fire-proof chest. This consisted of two chests, one so formed within the other as to have one or more spaces between them, to inclose air or any known non-conductors of heat. In the same year, one of these double chests was severely tested by being exposed in a large building in Thomaston, Maine, that was entirely destroyed by fire. The chest preserved its contents in good order. This excited the public admiration, and one enthusiastic writer described it as a "Salamander," which name has ever since been popularly applied to safes.

The majority of the so-called "safes" in use at the time of the great fire in New York, in 1835, were simply iron closets, and were of little protection against the devouring element. There were then about sixty of Gayler's *double chests* in use, and they earned a character by the success with which they preserved books and securities. The fire of 1835, notwithstanding, stimulated ingenuity in the construction of safes, and John Scott obtained a patent for the use of asbestos for fire-proof chests. He mixed that material with plaster of Paris and water, and spread it on from one to three inches thick, on a wooden foundation or box. The composition was then covered with sheet iron, secured by bands of bar iron. In the following year, Mr. James Mathews, of New York, patented a composition for fire-proof safes, consisting of Roman cement, soapstone, alum, and glue. In 1837, Benjamin Sherwood, of New York, obtained a patent for a circular revolving safe within a safe, and claimed the exclusive right to the use of boiled gypsum and pulverized charcoal in equal proportions, mixed with water, and poured into the space between the inner and outer plates of each safe. In 1840, B. G. Wilder obtained a patent for a construction known as the "Wilder Patent." This has had very good success. There are in New York two manufacturers of these—B. G. Wilder & Co., and A. S. Marvin & Co. In the same year, Mr. Fitzgerald got out a patent for the combination of a safe with a counting-house desk. In 1843, the same person obtained a patent for the use of plaster of Paris alone, or with mica, in the construction of fire-proof safes. In 1855, Holmes G. Butler patented an improvement in the mode of applying alum filling in safes. The Messrs. Spear, of Philadelphia, obtained a patent for the use of the residuum of the materials used in the making of soda water, for safes. There have been many patents obtained for the use of plaster of Paris, mixed with other substances. The leading articles used up to this time, however, are plaster of Paris, clay, and cement. These materials have furnished the manufacturers with the means of various combinations, for which greater or less advantages are claimed. The American safes are, no doubt, superior to those made in any other part of the world.

The main object of the safes enumerated has been protection against fire. In 1851, however, Lewis Lillie, of Troy, obtained a patent for a burglar-proof chilled-iron safe, that has come into vogue with the bankers. The mode of construction is peculiar. A foundation, or box, is made of bars of wrought iron, crossing each other at right angles, and placed near each other, so as to form a compact network. The inside of this box is filled with sand, and placed in a mould, with an open space of from one to two or more inches, all around the outside. Into this space is poured cast iron, which becomes thoroughly chilled and hard, like the ploughshare, and impervious to a drill. The door is made in the same manner, and secured by a Derby combination lock. There are other modes of combining the same materials for effecting the same object.

While this progress has been made in the construction of the chests, perhaps even greater progress has been made in the manufacture of locks to fasten them. The degree of ingenuity displayed in this branch has been very great; and, in this department, American genius has far surpassed that of other countries. In 1784, Mr. Bramah, in England, invented a lock, which was an ingenious modification of the old tumbler system. This was thought to be the greatest invention of the age, and was long regarded as proof against picking, until Mr. Hobbs, of Boston, picked it in 1851, and obtained the reward of two hundred guineas that had long been a standing offer for the accomplishment of that feat. In the United States, many inventions have been made, but the ingenuity of picking, or of demonstrating the weak points of the inventions, has progressed in as great a degree. In 1841, Dr. Andrews, of Perth Amboy, produced locks on what was called the "permutation" principle. On this principle the key is made with rings, which may be changed on the key, and the lock cannot then be opened without readjusting the rings as before. This lock was for some years in great repute. Robert Newall, of New York, about the same time invented a more complicated lock on the same principle. This was carried to a high degree of perfection. It proved, however, only an incentive to a greater exercise of genius, since the same gentleman having picked Dr. Andrews' lock, ended by picking his own. He then introduced an intermediate or detached tumbler principle, which he supposed unpickable. This was taken in hand by William Hall, of Boston, who opened it by the application of the "smoke process," by which

a smoky flame is introduced by the key-hole, and this leaves a fine deposit of lamp-black upon the "bellies" of the tumblers. When the key is next introduced, it removes the lamp-black from the parts it touches. By means of a small reflector, a strong light is then thrown in, bringing the key marks to view. The exact sizes for a false key are thus obtained. To prevent this operation, it was supposed that concealing the tumblers would be all that was requisite. H. C. Jones, of Newark, accomplished this by concentric rings and curtain; and Pyes did it more effectually with eccentric rings and curtain. The lock was now thought perfect. It was called the parautoptic (concealed from view) lock. A. C. Hobbs, with one of these at the English exhibition of 1851, defied the best English operators. One of these locks was used at the Bank of England, and they came into general use in the United States. In 1855, Linus Yale, jr., of Philadelphia, by means of the impression process, picked this great lock. In 1843, Linus Yale, senior, patented a "pin" lock and then the duplex lock, for which two keys are required. One being introduced, it was necessary to unscrew and remove its handle, then close the key-hole entirely with a hardened plate, before the other key-hole could open. The ingenuity of his son dispelled the idea that this was absolutely secure, by picking it. Yale, jr., being convinced that no lock is secure so long as the shape of the key prevents the entire closing of the hole, he set to work upon that principle, and in 1851 he invented the magic lock. In this lock, the key and its bits appear as of one piece; on being introduced into the lock, the bits are taken up by a pin, which enters through them into the centre of the key-shaft. The key then being turned in the usual manner, puts in motion a set of gear wheels. These first separate the bits from the key, and then carry them into the interior of the lock, away from the key-hole. They there operate upon the tumblers out of sight and beyond the reach of any picking tools. The same motion which carries away the bits effectually closes the key-hole. When the bolt is passed, the key-hole re-opens, the bits come back and join the handle to be taken out, as they were put in. The bits may be taken away in the pocket, if desired, leaving the handle with the lock. This mechanism seems to effect perfectly the conditions sought for security against picking. E. B. Denison, the famous clockmaker, of London, remarks in relation to this, as well as to Newell's, "that the casting of both these American locks (which have all their heavy parts of cast iron) is vastly superior to any iron castings we have ever seen made in England; and, on the whole, the United States are evidently far ahead of us in the manufacture of both good and cheap locks." This is certainly very gratifying praise to the national pride, when we reflect how few years since we depended entirely upon England for bank locks.

In some cases, burglars introduce strong tools to force locks apart, and others introduce gunpowder to explode them. A device against this is to form a strong slider of cast steel to close the key-hole, and also to cut out a piece of the back plate and screw it on again, with small screws. This giving way on the application of force, saves the rest.

These brilliant inventions have been made to close the doors of safes against burglars, while the improvements in the boxes guard against fire.

GLASS MANUFACTURE.

When we contemplate by turns each of the great materials most conducive to man's advancement in civilization, we are at times lost in the attempt to give precedence to any one, since so many have held so high a rank in the scale of usefulness. Iron has, perhaps, been the most important in respect of industrial purposes, and paper has been the means of recording and promoting that general intelligence without which progress could not be very extensive, but glass has entered more into the necessities of science, as well as those of social life and every-day comforts, than most materials. The great properties of glass are its transparency, its hardness, its power of assuming any possible form when hot, and its non-conductibility. Employed as windows, it transmits light into our dwellings while protecting us from the inclemency of the seasons and permitting a view of exterior objects; wrought into the form of vessels, it preserves all liquids without alteration, while we can inspect the contents. This quality, added to its indestructibility by any of the acids (except fluoric), has much facilitated the investigations of chemists. The physical sciences are not less indebted to it. It is the principal auxiliary

of optics. With his glass prism, Newton decomposed light; it is by its means that astronomy makes its observations and discoveries in the infinity of space; combined in the microscope, it carries the vision of the naturalist into the most minute formations of nature; with it, those of short sight have the perception extended, and by it, the flattened vision of age is restored to its natural powers. To the science of fluids it is indispensable, and most of the experiments in caloric and electricity are due to its agency. If all the sciences are more or less dependent upon it, the ordinary usages of life are no less promoted by it. It gives mirrors for the toilet and for ornament to houses; it serves the table with liquids; it preserves works of art from the dust, ornaments lustres, and with it the precious stones can be imitated in all respects but in their hardness. In the arts its wonderfully varied powers may be put in requisition for almost all purposes, from the delicate spring of a chronometer watch to the heavy pipes for supplying water to cities. For the former purpose, its insensibility to climate and temperature gives it advantages over the metals used for that purpose.

The use of glass is of a very remote antiquity—how remote is left to conjecture. It had been supposed that the ancients were not acquainted with its use. Glass beads have, however, been found on mummies more than 3000 years old, and in the ruins of Nineveh bottles and vases have been found of glass; and the exhumations of Pompeii and Herculaneum disclosed the fact that it was in those cities used for windows, as well as for very numerous utensils, all of which gave evidence of great skill in glass work. The manufacture of glass spread from Italy to other countries of Europe, at first into Gaul. Bohemia was, however, possessed of the best materials in the greatest abundance, and the manufacture settled and acquired for Bohemian glass a reputation which has come down to our times for vessels. The use of glass for mirrors seems to have originated in Venice.

The manufacture of glass was carried on in England as early as 1439, according to Horace Walpole. Flint glass was made in London in the middle of the 16th century, and the manufacture of plate glass was commenced by the Duke of Buckingham, who imported Venetian workmen. Since then great progress has been made, and English flint glass has won a great reputation. The manufacture was one of the earliest introduced into the colonies. At Jamestown, Va., a glass-house was broken up by an irruption of Indians in 1632. There appears, however, to have been no accurate account of any until that of Mr. Hewes, of Boston, in Temple, N. H., 1780. Those works were operated by Hessians and Waldeckers, deserters from the British army; and one of the first articles there produced is now the property of Harvard University. Washington, in his diary, 1789, alludes to a glass-house in New Haven. In 1803 a German, of the name of Lint, undertook glassworks in Boston, and the state made him a bounty on every table of window glass made. From that time the works prospered, or at least were sustained.

The manufacture of crown glass was early commenced at Pittsburg, Pa., by Colonel O'Hara, who, in 1798, started glassworks in that city, to which the materials were brought from 30 to 100 miles' distance. The concern had a considerable success, and was followed by others until, in 1814, there were five glassworks at that place. In 1812, Messrs. Bakewell & Co. established at Pittsburg the first flint-glassworks in the Union. They brought the manufacture to great perfection, bringing out workmen from Europe at high wages. The style of cutting and engraving was thought equal to the foreign, and the operations of the house extended until the works became the largest for glass manufacture in the country. There were there made sets of glass for two Presidents of the United States; and a set of splendid vases there produced 40 years since, still adorns the saloon at La Grange, the seat of Lafayette. The house have also received the silver medal of the Franklin Institute. In other parts of the country the manufacture progressed to a greater or less extent, and in 1832 a committee of the New York convention made a report on the glass manufacture, from which it appears there were then in operation 21 glass furnaces, having 140 pots for the manufacture of crown glass; of these, 6 were at Boston. There were also in operation 23 for the manufacture of cylinder glass; of these, 10 were in Pennsylvania, 2 at Wheeling, 2 in Maryland, 2 in New York, 2 in Ohio, 1 in Massachusetts, 1 in New Hampshire, 1 in Vermont, 1 in Connecticut, and 1 in the District of Columbia. The whole value of flint glass then produced was given at $1,350,000. The

most extensive green bottle factory was at that time Mr. Dyott's, near Philadelphia. There were there melted 4 tons per day, or 1200 tons per annum. At that period the glass manufacture received an impulse, and in 1834 there were 6 works at Pittsburg, making crown and cylinder glass, green bottles, and apothecaries' phials. One bottle factory produced 1600 dozen weekly, and a phial factory 2200 gross weekly. There were also produced in one concern 5000 boxes window glass annually, of a quality nearly equal to the best crown glass. There were also at Wheeling 2 crown and flint-glassworks, and 1 for phials and bottles. At Wellsburg, 16 miles distant, there were 1 flint glass and 1 green bottle factory.

The census of 1840 showed that there were then in the United States 81 glass-houses, employing 3,236 men. The aggregate capital was given at $2,014,100. Of these, 2 were in Virginia, 28 in Pennsylvania, 25 in New Jersey, 13 in New York, 2 in Vermont, 3 in Connecticut, 4 in Massachusetts, 3 in New Hampshire, and 1 in Michigan. The census did not distinguish the different branches of the glass manufacture, nor the modes of making window glass. The increase up to 1850, by the census of that year, appears to have been not very considerable. The number of works had risen to 94, with an aggregate capital of $3,402,350, employing 5571 men, and producing a value of $4,641,676 per annum. Of these 94 establishments, 28 were in Pennsylvania, and 20 more in New Jersey, mostly owned in Philadelphia; 18 were in New York, 6 in Massachusetts, 2 in Maryland, 1 in Connecticut, 4 in New Hampshire, 2 in Missouri, 6 in Ohio, 6 in Virginia, and 1 in Tennessee. The glass manufacture thus concentrates apparently in Pennsylvania. There has been in the last ten years some progress. In 1853 the first plate glass manufactory in the United States was established at Cheshire, Berkshire county, Mass. The same company now are at Lenox under the name of the "Lenox Rough Plate Glass Co." The rough or hammered plate glass manufacture has also been recently established in Philadelphia; also a new description, called "German flint," of less beauty than the old flint, but better adapted for the use of apothecaries, chemists, perfumers, etc., since it is little affected by acids and alkalies.

The materials for glass are several; the chief, silica, obtained from the sea beaches in the form of quartz sand, and from the quartz rocks of the interior. The name of "flint glass," which originated with the English manufacturers, and long held the highest rank in Europe, came from the use of flints, calcined and ground to powder. This process is now supplanted by the use of sand, of which a highly prized article is imported into England from Austria. The purest article used in the United States is obtained from Lanesborough, Mass., being a disintegrated quartz rock. It is easily broken by the pick, and the lumps may be crushed in the hand. The grains are remarkable for their purity. They appear white in the mass, but under the microscope each appears as limpid as crystal. This is used for the best flint and plate glass. Lime is used in the shape of limestone of the purest qualities, or as quicklime. Potash is derived from common wood ashes, and the ashes of sea-plants supply soda. Pearlash is sometimes used; also the refined alkalies. Common salt is used whence to extract carbonate of soda. In addition to these, saltpetre, alumina, and waste glass, enter into the ingredients of glass, the proportions of many kinds of which are as follows:—

English bottle glass—sand, 100 lbs.; lixiviated ashes, 100; wood ashes 40; kelp, 40; clay, 80; cullet, or waste glass, 100. For Bohemian crystal, are used—100 lbs. sand; purified potash, 60; chalk, 8; cullet and manganese, 40. In window glass, are used—100 lbs. sand; chalk, 40; carbonate of soda, 35; of broken glass, from 60 to 180; and some manganese and arsenic. For plate glass—Lynn sand, washed and dried, 720 lbs.; alkaline salt, of which 40 per cent. soda, 450 lbs.; lime, 80; nitre, 25; broken plate glass, 425. These will give 1200 lbs. of glass. For Faraday's heavy optical glass—protoxide of lead, 140 lbs.; silicate of lead, 24; dry boracic acid, 25; and 100 lbs. of sand. Artificial gems are composed of 100 lbs. of quartz crystal, or sand; pure minium, or red lead, 154 lbs.; caustic potash, 54 lbs.; boracic acid, 7; and some arsenious acid. These are a few of the proportions used, but most manufacturers modify them in various ways, since the same compound will, in the same furnace, under different conditions of fuel, draft, and weather, give different results. Bituminous coal, or coke, or seasoned wood, may be used for fuel, and firewood is preferred. In some glassworks of the

United States, rosin is preferred to all other fuel, since when pulverized it may be added in small quantities at a time. It burns without giving off impurities that may mix with or injure the glass, and it leaves no residuum.

In proceeding to manufacture, when the combination of materials is formed, they are thoroughly ground, mixed together, and sifted. The glass furnace is a large circular dome, in the centre of which is the fire. This is surrounded by 8 to 12 melting pots, which being raised to a white heat, receive the mixed glass in quantities about one eighth at a time. As each instalment melts down, the others are added. The entire quantity being melted, the fires are urged to the utmost, while the workmen watch the operation, with long iron rods, by means of which they extract from the boiling mass portions, from time to time, until transparency, on cooling, indicates that perfect fusion of all the materials has taken place. A scum rises during the boiling which is removed as it appears. The heat is then raised to the highest degree, to perfect the fusion. The glass is now made, but it contains many impurities, being substances that would not melt; and there is also still a quantity of gas, which, if not got rid of, will form those bubbles that are sometimes seen in common window glass. The mass is therefore kept fluid during some 48 hours, by which means the "metal" is fined, that is, all the bubbles of gas will have disappeared, and insoluble matters will have settled to the bottom. The heat is then allowed to subside until the metal becomes thick enough to work, at which point the temperature is maintained in order to keep the glass in this condition. The pots that surround the furnace will generally thus hold enough to employ the force day and night for the first four days of the week, the hands being divided into gangs that relieve each other every six hours.

The glass materials, being thus brought into suitable combination, are ready for some of the numerous branches of manipulation in which that article is employed—the manufacture of window glass, plate glass, bottles, phials, flint glass, vessels of all descriptions, gems, optical instruments, etc. The manufacture of window glass is perhaps the most extensive, and this is conducted in two modes. By one the glass is blown into "tables," like cart wheels, and by the other it is formed into cylinders, that are cut open lengthwise and flattened out. The former is the more generally practised. That description is generally known as English crown glass. In the manufacture, the melting pots, of which there are usually eight, hold about half a ton of metal each, and this will suffice for 100 tables of crown glass. When the glass is in its proper state, the workman is armed with a pipe, or blowing tube, 4 or 5 feet long, with a bore $\frac{1}{4}$ to 1 inch in diameter, and a little larger at the mouth end than at the other. It is, as it were, a long hand, with which, the end being heated red hot, the workman reaches into the pot of melted matter, and gathers up the quantity he requires. By long experience he is enabled to do this with great exactness, and this, for crown glass, will not vary much from 9 lbs. The pipe being cooled to admit of handling, the lump is rolled upon the *marver* (which is a polished cast-iron slab), to give it a conical form. Blowing through the tube, at the same time, causes the lump to swell. It is then heated in the furnace, and again rolled and enlarged by blowing. In this operation, the portion next the tube becomes hollow, and the greater portion of the glass works toward the point of the cone it forms in rolling. The solid point is called the bullion. This being softened in the furnace, the tube is laid across a rest, and made to revolve, while the glass is blown to a globe. During this operation, a boy supports the soft end, or bullion, with an iron rod. The globe, by continually revolving, increases in size, and flattens out, the bullion point still forming a thick centre, to which an iron rod, called a pontil, which has a little molten glass on its end, is applied; at the same moment the globe being separated from the blow pipe by the application of a piece of cold iron to its "nose," remains upon the pontil. As the tube breaks away, it leaves a circular opening, which the workman, holding by the pontil, presents to the furnace. By this means it is softened almost to melting, and being made to revolve rapidly, the opening grows rapidly larger by centrifugal force. The heated air in the globe prevents the two opposite faces from coming together. The portion next the fire appears to roll inside out, and it suddenly, with a noise like opening a wet umbrella, flattens out into a circular disk, which is then removed from the fire, and kept revolving until it is cold. The pontil is then cracked off, and the disk removed to the annealing oven, and set up on edge with the rest, ar-

ranged in rows, and supported by iron rods, so as not to press against each other. The annealing is completed in 24 to 48 hours. These "tables" are generally 52 inches in diameter; sometimes, however, as much as 70 inches.

Plate glass imperfectly annealed will, when once cracked, soon fall all to pieces. The annealing process is simply to place the hot glass in a hot oven, and allow the whole to cool gradually. By this operation it is found that glass is deprived of much of its brittleness. The explanation is, that the glass is a non-conductor, and when made, the exterior cools first, forming a crystalline crust which shelters the interior particles, so that these continue longer in the fluid state, and are prevented from expanding as glass usually does when it cools. The interior has thus a constant tendency to expand or burst out. When the whole is allowed to cool slowly in an oven, all the fibres of the glass assume their proper and natural places, and the mass becomes tough and elastic. The effect of sudden cooling is manifest in the toys called "Prince Rupert's drops." These are simply hot glass dropped into water. In so doing, most of the drops burst to pieces, but some retain a pear shape. These, when taken out, will bear a smart blow without breaking; but the smallest break at the stem will cause the whole to fly to pieces with a loud explosion. Bologna phials are formed of unannealed glass 4 or 5 inches long, and ⅛ inch thick. These will bear a hard blow, or a bullet may be safely dropped in. If, however, a sharp fragment of sand is introduced, the phial will fly to pieces. Annealing deprives them of these qualities.

From the annealing kiln the tables go to the warehouse, and are there assorted according to defects and qualities. Each one is then laid in turn upon a "nest" or cushion, and is divided by a diamond into two pieces, one of which, the larger, contains the bull's eye. These are then cut into square panes. The circular shape and the bull's eye involve much waste in cutting. The glass thus manufactured, however, has a remarkable brilliancy, and for that reason it is preferred to the cylinder process, by which, however, larger panes are made.

The cylinder process has been pursued to a great extent in the United States. It is practised by a number of workmen. Sometimes 10 are arranged side by side, with a raised platform extended in front of the furnaces 10 feet above the bottom. Standing upon this, each man gathers a proper quantity of metal from the pot before him. By applying the lump to a wooden mould and blowing, it takes a globe form. This he heats, and then holds upon the pipe vertically over his head, at the same time blowing into it. This causes the globe to flatten. It is then held down so as to swing below the platform on which the worker stands. This, with continued blowing, causes the glass to elongate in the form of a cylinder. The workman watches with care lest the elongation should proceed too rapidly, in which case he raises it again over his head. This operation is dexterously continued until the cylinder attains 47 inches in length, and 10 inches in diameter. The end is then softened in the fire, while the pipe is closed with the thumb. The air within the cylinder then expands so as to burst out the end. The edges of the opening thus caused are then spread and trimmed. The tube end is cut off when the glass is cool by the application of a hot iron, and letting fall a drop of water on the heated line. The cylinder is now to be cut open lengthwise in order that it may be flattened out into a pane. For this purpose two methods may be employed —one with the hot iron and cold water, and the other by a diamond applied inside the cylinder along a rule. The cylinders are now carried to the flattening furnace, where they are laid, slit uppermost, on the flattening stone. Here, as they soften, they open out, and a workman with an iron rod aids the operation. Another at the same time, with a rod having a block of wood at the end for polishing the sheets, works down the irregularities of the surface. The sheet is then passed into the annealing oven. In every stage of this process, the sheets are exposed to imperfections, and, in consequence, few are perfect. Most answer for inferior uses. None have the brilliancy of crown glass. The main difficulty is in the wrinkling. The glass being made in the cylinder form, the inner and outer surfaces are of unequal lengths. In the flattening out, this inequality produces undulations, called cockles, which distort objects seen through the glass. The unevenness also made it very troublesome to polish the surface until the difficulty was overcome by the device of pressing upon each sheet soft leather, which, acting like a boy's "sucker,"

adheres to the glass by atmospheric pressure. Two plates thus held are laid face to face, and, by the action of machinery, rapidly rubbed together with the intervention of polishing sand and water. By this means a beautiful polish is bestowed.

By these two methods of manufacture most of the glass used in the United States is produced. For the city dwellings of the more wealthy, as well as for the large stores and shops, plate glass is used; but the demand is small compared with the quantities used in the United States for the rapidly multiplying dwellings. Thus the average number of square feet of glass for a dwelling may be placed at 100. The number of houses in the United States in 1850 was 3,363,427, which would require, in round numbers, 336,000,000 feet. In 1860 the number of dwellings was about 4,700,000, requiring 470,000,000 feet of glass, or an increase of 134,000,000 feet for new dwellings alone, without taking into account breakage, rebuilding, churches, hot-houses, public buildings, etc. The value of the new glass required would be about $4,500,000. On account of this large demand, the imports continue considerable, and were in 1858, 19,734,439 square feet, at a value of $626,747. In the same year the export of domestic glass was $214,608.

Various causes affect the combination and the qualities of the compounds. The alkali in window glass, powdered and moistened, is detected by its action upon turmeric paper, and may be dissolved out by boiling water. Atmospheric agents sometimes remove it in part from window panes, leaving a film of silicate of lime. The glass of stable windows is liable to change its appearance and assume prismatic colors from the action of the ammoniacal vapors upon the silica. When moderately heated, glass is readily broken in any direction by the sudden contraction produced by the prompt application of a cold body to its surface. It is divided, when cold, by breaking it along lines cut to a slight depth by a diamond or some other extremely hard-pointed body. It may be bored with a steel drill kept slightly moistened with water, which forms a paste with the powder produced. Copper tubes, fed with emery, also serve to bore holes in glass.

As very large panes of glass could be made by neither of the above methods, the large plate glass used for mirrors and for shop windows is cast. The mixtures employed do not vary much from those used in sheet glass. A larger proportion of soda is used; but this pushed to excess gives a greenish tinge. The greatest care is taken in the selection of the materials. When the glass is melted in the pots, it is ladled into cisterns or *cuvettes* placed in the fire by the side of the pots. Some manufacturers allow the metal to remain fluid in the pots 16 hours, and an equal time in the *cuvettes*; and in some cases, in order to allow the soda to volatilize and the air bubbles to escape, the time is prolonged to 48 hours. When nearly ready, the temperature of the glass is allowed to fall in order that the material may assume a pasty consistency. Meantime, the casting plate is prepared. This is usually a cast-iron plate, perhaps 7 inches thick, 11 feet broad, and 20 feet long. It has raised edges to prevent the glass from flowing off, of a depth proportioned to the proposed thickness of the glass plate. On a level with this table, and arranged along its side, are the annealing ovens. Each of these is 16 feet wide and 40 feet deep. Hot coals are heaped upon the plate to bring it to a proper temperature. The cistern swung on a crane is then approached to the table, which is thoroughly cleaned, and the melted glass carefully skimmed with a copper blade. By canting the cistern, the glass is then poured upon the table. A copper cylinder 3 feet in diameter extends across the table, resting on the raised edges. This, being rolled forward, sweeps before it the excess of glass, spreading the whole uniformly of a thickness governed by the raised edges of the table. The effect of the passage of the copper roller upon the brilliant surface of the glass is very beautiful, leaving, as it does, a splendid play of colors. The superfluous glass being then trimmed from the edges, the plate is thrust forward into the annealing oven previously raised to a red heat. Successive plates are thus cast until the annealing oven is full, when it is closed up and left 5 days to cool. When taken from the oven the plates are examined for defects, and the mode of cutting decided upon is then done with a diamond.

There are many modes of grinding and polishing, but in this, as in most other arts, the latest improvement is an American invention, which, highly successful here, was introduced into England in 1856. A circular plate of cast iron, 10 feet in diameter and

2 inches thick, is secured upon the upper end of a vertical shaft, so as to revolve with it. Above the table, frames are arranged to hold the plates of glass, which are laid in a bed of plaster of Paris, with the face to be polished resting upon the revolving table. The frames are so arranged that the friction of the table upon the glass causes them to revolve so as to present every portion of the glass surface to an equal amount of rubbing. When sand is required to grind down the glass, it is fed in from a box above the frame. This is found to be the best mode; but sometimes the surfaces of the plates are ground together. After grinding, they are smoothed with emery powders of successive fineness until they are ready for polishing. This, in the American machinery, is performed by rings coated with felt and screwed to the surface of the iron table. Oxide of iron or rouge is applied to the felt as a polishing agency. When this is completed they are ready for silvering.

In the process of silvering, a large stone table is prepared so as to be canted, by means of a screw beneath it, on one side. Around the edges of the table is a groove, in which quicksilver may flow, and drop from one corner into bowls placed to receive it. The table, being made perfectly horizontal, is covered with tin foil carefully laid over it. A strip of glass is placed along each of three sides of the foil to prevent the mercury from flowing off. The metal is then with ladles poured upon the foil until it is a quarter of an inch deep, and its tendency to flow is checked by its affinity for the tin foil. The plate of glass, well cleaned, is dexterously slidden on from the open side. Its advancing edge is carefully kept in the quicksilver, so that no air or any impurities can get between the metal and the glass. When exactly in its place it is held until one edge of the table is raised 10 or 15 degrees, and the superfluous metal has run off. Heavy weights are then placed on the glass, and it is so left several hours. It is then turned over, and placed upon a frame, the metal uppermost, which becomes hard in the course of several weeks. Patents have been taken out for precipitating silver upon the glass, but this process is not so successful as the old.

When these plates are used for shop windows, some of them require to be bent in various manners. This is a separate branch of business, and is carried on at Newark, N. J., extensively. The bed is made of suitable material, on the floor of the furnace, and made in the required form. The sheet of glass is laid upon this, and as it softens in the heat, it assumes the form of the bed on which it is laid.

The manufacture of flint glass for domestic purposes requires great care in the selection of the materials. It possesses the properties of great transparency and high refractive power. Its brilliancy and density are in some degree due to the introduction of oxide of lead. Oxide of zinc has also been found effective for the same purpose. In order to protect the glass from effects of smoke or other elements which might discolor it, it is melted in a covered pot, with an opening in a short neck on one side. The heat is made very intense that the fusion may be rapid. The moment fusion and fining have thoroughly taken place, the heat is reduced, to prevent the deleterious action of the materials of the vessel upon the glass. In the United States, when the metal is taken out by the workmen, it is shaped in the required form by pressing into a die. For this purpose, when the article is large, considerable pressure is required. The experience and skill of the workman are put to the test in taking up just the quantity of metal required to fill the mould, which is kept at a red heat. The objects, being formed, go through the cutting process, as it is called, but really the grinding process. Circular stones or metallic disks are made to revolve, being fed with sand and water for coarse grinding, and emery for finer work. The marks left in the coarse grinding are removed by application to wooden revolving wheels, fed with pumice or rotten-stone, and finally with putty powder, a preparation of tin and lead. The fine polishing of chandelier drops, and similar ornaments, is effected by a lead wheel, supplied with rotten-stone and water. Globes and lamp shades are polished on the inside by filling them with sand, and placing them in a drum, which revolves rapidly for a length of time.

The glass most important in the arts is certainly that used for optical instruments. Flint and crown glass are both used for that purpose, but both have their defects. Those of the former arise from the difficulty of effecting uniform fusion, and crown glass is seldom possessed of the requisite uniformity of texture. These difficulties were so great that, until the early part of the present cen-

tury lenses larger than three and a half inches could not be made. At that time a Swiss clockmaker, Guinand, produced them as large as nine inches, of the greatest perfection. The secret remained with him for a long time, but was finally, by one of his sons, imparted to M. Bontemps, who in 1828 produced lenses of twelve to fourteen inches. The secret was in keeping the mixture actively stirred when liquid, and then suffering it to cool and anneal in the pot. Lenses are now made of flint glass twenty-nine inches in diameter, and weighing two cwt.

The production of vessels of colored glass is conducted in a very ingenious manner. The coloring matters are various. Blue transparent glass is made with 2 lbs. oxide of cobalt; azure blue, 4 lbs. oxide of copper; ruby red, 4 ozs. oxide of gold; other colors by various combinations. Sometimes the color is incorporated merely with the outer portion of the glass. This is effected in the blowing by dipping the lump of clear glass, when shaped upon the marver, into the pot of melted colored glass, and then blowing it to the shape required, and flashing out, if desired to convert it into panes. The color may afterward be reduced in depth by grinding, and clear spots reached by grinding through the color. In the process of "casing," a portion of partially blown flint glass is inserted into a thin shell of colored glass, and then blown until it fills the shell, with which it becomes incorporated by heating and further blowing; casings of different colors may be thus applied. In painting, the color, mixed with a flux that will fuse at a lower temperature than the glass, and with boiled oil, is laid on with a brush as in ordinary painting, or by blocks as in calico printing. The glass is then heated, when the flux melts, and sinks into the body. The painting of glass for church windows was formerly carried to a high degree of excellence, that moderns have not been able to equal. Although the receipts have been preserved in ancient treatises, the process has been lost.

Enamelled glass has of late been much used. The glass of the New York Crystal Palace is an illustration. In this process the enamel substance is ground to an impalpable powder, and then laid with a brush, in a pasty state, upon the glass. After the paste is dried, the ornament is etched out either by hand or by machinery. The glass being then softened in the intense heat of the furnace, the enamel becomes vitrified and incorporated with it. It then passes to the annealing furnace. This process was invented by Mr. William Cooper, of the firm of Cooper & Belcher, New York, whose extensive works at Newark, N. J., supplied 60,000 feet for the New York Crystal Palace. Another variety, the flocked, has now come more into use. The process is nearly the same, except that a smooth opaque surface is given to the glass before the enamel is applied.

Soluble glass has been made of later years of equal parts silica and caustic potash. This is soluble in boiling water, and is used extensively for making buildings and all combustible bodies fire-proof.

In the manufacture of bottles, the metal, on being withdrawn from the melting pot on the end of the blowing tube, is, if for common black bottles, shaped in concavities that are made in the edge of the marver. Fine bottles of flint glass are shaped in moulds of brass or iron, which are made in two parts hinged together, so that they may be opened and shut with the foot. Bottles for champagne, soda water, etc., are made of extraordinary strength, and tested before using by hydraulic pressure. They ought to support, for this purpose, a pressure of 40 atmospheres, or 600 lbs. on the square inch. Notwithstanding the great strength with which they are usually made, the breakage in the manufacture of champagne is rated at 30 per cent.

The glass is drawn out into tubes in a manner that illustrates the curious manipulations of the metal. The workman, with his blowing tube, accumulates a certain quantity by successive dips into the melting pot. This is then blown into a globe. Another workman then takes hold with a pontil, at a point exactly opposite the blowing tube. The two men then separate, and the globe contracts in the middle, which being drawn out to the size of the tube desired, cools, and the hotter portions successively yield to the drawing, until a tube of 100 feet or more hangs between the workmen. The diameter of the bore retains its proportion to the thickness of the glass; hence thin tubes must be drawn from globes blown to a large size. These tubes of colored glass may be converted into beads. Beads have always been a great element in the trade with the North American Indians, being highly prized by them.

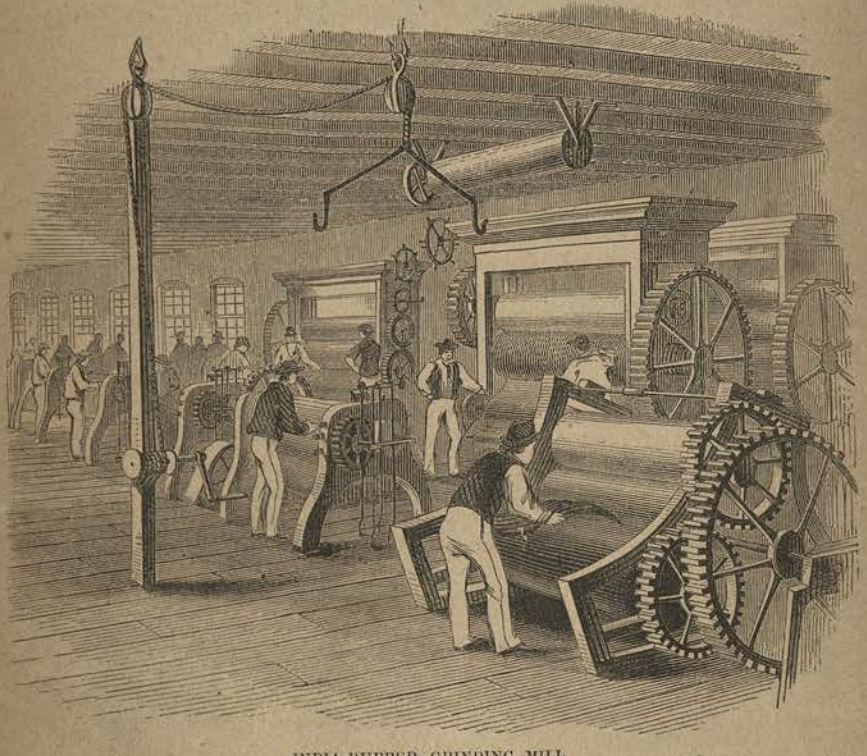
INDIA-RUBBER AND ITS MANUFACTURE.

One of the most remarkable American discoveries of the present century is, undoubtedly, the mode of manufacturing and applying the article known to commerce as "India-rubber," but which, among the people of South America, is called "caoutchouc." The article in question is a gum procured from a peculiar tree in the hottest regions of the equator. The tree which yields this gum in the East Indies is somewhat different from that which produces it in the equatorial regions of South America. The form of both these plants is delineated in an engraving on another page. Although the gum was used in a rude fashion since many ages by the inhabitants of the countries which produce it (and it had been known to commerce for a long time, having been discovered by a French philosopher in 1736), it is only within 20 years that its value has been appreciated. In that time, under the genius of American manufacturers, it has risen to a rank equal, perhaps, to that of iron and glass among the materials that administer to the necessities and comforts of man.

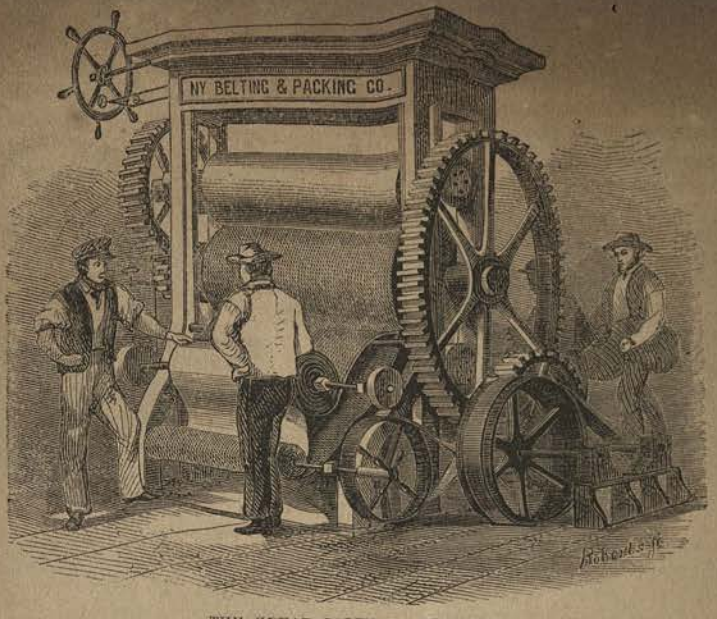
In the forests of equatorial South America the "siphonia elastica" grows to a height of 60 or 70 feet, and is covered with a scaly bark. It bears a fruit, which encloses a white almond highly esteemed by the natives. A slight wound on this tree causes the sap to flow freely, thick, white, and unctuous, like the sap of the milk-weed. On being exposed to the air, this soon becomes solid. This sap is collected by the natives, who make a longitudinal cut in the centre of the tree, and lateral cuts leading diagonally into it. At the bottom of the perpendicular cut a banana leaf is placed to conduct the sap, as it flows, into a vessel placed to receive it. The sap is used for the formation of bottles, boots, shoes, and various articles. The process is to form the figure of the thing desired in clay; cover it on the outside with many coats of the gum, exposing it to fire to dry. When the desired thickness is obtained, the mould is soaked out in water, and the article is ready for use. Clumsy shoes, rudely fashioned in this manner, were long an article of importation from Para into the United States, and extensively sold down to within 25 years. There was little other use made of the article except to erase pencil marks, and for which purpose was charged 50 cents for ½ a cubic inch. The nature of the gum did not, however, long fail to become an object of research. The learned decided that it was neither gum nor resin, but of a peculiar nature analogous to resin, from which it differed in not being soluble in alcohol. Many attempts to make it useful in the arts were made, and finally it was found that by dissolving it in volatile oil there was obtained a sort of varnish very useful in making certain tissues and fabrics water-proof. A thin coat, placed between two sheets of stuff, caused them to adhere closely and made them impervious as well to water as to air. This application of it was made in the manufacture of mattresses, cushions, pillows, boots, bottles, etc. A solution in linseed oil is called an excellent varnish for making leather water-tight. The best solvents are said, however, to be oil of turpentine, coal, naphtha, and benzole. Alcohol will not dissolve it, but will precipitate it from ether. Another solvent is of rubber itself, called caoutchoucin. It is produced by exposing rubber to a heat of 600°, when it goes off in a vapor, which, being condensed, produces the solvent. All these applications, however, utilized only one of the distinguishing properties of rubber, viz., its imperviousness to water. An inventor, however, by the aid of a new solvent, found means to spin threads of the rubber of various degrees of fineness and strength. These threads, covered with textile fabrics—silk, wool, cotton, or linen—became light and supple tissues of extraordinary elasticity. This opened the way to an immense number of employments.

In some machines the rubber is kneaded, and compressed in various ways, and finally a number of the balls thus treated are brought together and powerfully squeezed by a screw press in cast-iron moulds, in which, being firmly secured, the mass is left several days. This process is somewhat modified in different establishments. In some, the cleaned shreds are rolled into sheets, from which threads and thin rubber are sliced by the application of suitable knives, worked by machines, and kept wet. The sheets are at once ready for the purpose to which this form is applied, or, by machinery of great ingenuity, they are cut into long threads of any desired degree of fineness. If then required to be joined, a clean oblique cut is made, with a pair of scissors, and the parts being brought together, readily and perfectly unite by the pressure of the fingers. As

MACHINE FOR WASHING INDIA-RUBBER.

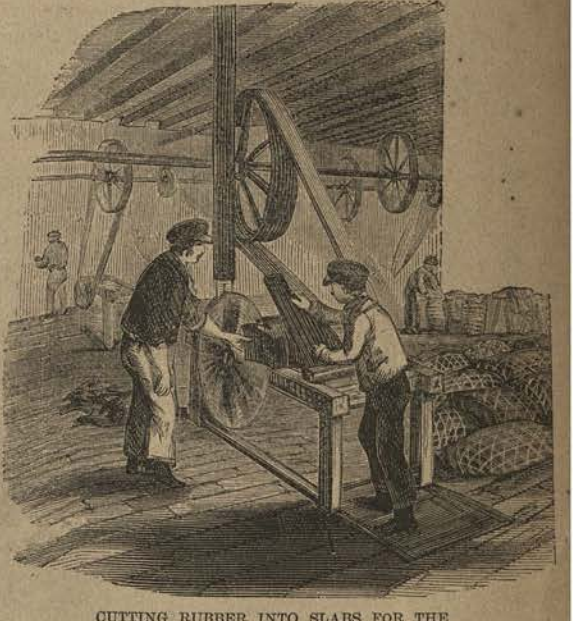


INDIA-RUBBER GRINDING MILL.



THE GREAT CALENDER MACHINE.

FICUS ELASTICA, FROM THE EAST INDIES.



CUTTING RUBBER INTO SLABS FOR THE WASHING MACHINES.

the threads are reeled off, they are elongated about eight times their original length by passing through the hands of a boy, and by the same operation they are deprived of their elasticity. After remaining on the reel some days, they are wound upon bobbins, and are then ready for weaving and braiding. The threads are of different fineness. A pound of caoutchouc can, by one machine, be made into 8000 yards of thread. This may, by another, be divided by 4, making 32,000 yards. Elastic braids are these threads covered with silk and other material. In woven fabrics, caoutchouc thread makes the warp, alternately with threads of stuff to receive the extreme strain that would destroy the rubber, and the other materials form the weft, or cross-threads. When woven, a hot iron is passed over the stuff, and this causes the rubber to regain its elasticity. Another mode of forming the threads perfectly round and smooth, is to convert the caoutchouc into a soft paste. This is done by macerating it for some hours with about twice its weight of sulphuret of carbon, adding 5 per cent. of alcohol. The paste is well kneaded by compressing it through diaphragms of wire gauze, placed in cylinders, and is then forced through a line of small holes at the bottom of another cylinder. The threads, as they issue, are taken on a web of velvet, from which they pass to another of common cloth, and are carried slowly along for 600 to 700 feet, when becoming dry and hard by the evaporation of the solvent, they are received in a little cup. The threads produced of vulcanized rubber retain their elasticity, and are, when woven, kept stretched by weights. On releasing them, the material woven with them is drawn back, producing shirred or corrugated fabrics.

Caoutchouc supplanted the metal elastics for many purposes, since it would not corrode in moisture. It was at once in demand for suspenders, garters, corsets, and numberless appurtenances of apparel.

It came to be used for water-proofing cloths, surgical instruments of all kinds, elastic bands, in the arts and trades. Bookbinders have used it for securing the leaves in books, imparting flexibility and freedom to the opening volumes. In thin sheets, it has been used for taking impressions of engravings. In this form, also, it is an excellent material for covering the mouths of bottles, and similar applications requiring the exclusion of air and moisture. Prepared with other ingredients, it forms a marine glue unsurpassed in adhesiveness when applied to wood. A pound of fine rubber is dissolved in four gallons of rectified coal-tar naphtha and well mixed. In ten or twelve days this will attain the consistency of cream, when an equal weight of shellac is added. It is then heated in an iron vessel having a discharge pipe at the bottom. As it melts, it is kept well stirred, and the liquid flowing out is obtained in the form of thin sheets. When it is applied, it is heated to 248° and applied with a brush, and retained soft until the jointing is made, by passing heated rollers over the surface. This has been, it is said, applied to masts of vessels, which have been so firmly spliced that fractures take place in the new wood sooner than to separate the glued portion; and it has been held that parts of vessels may be, by these means, so firmly put together that iron bolts would be unnecessary.

Rubber has been made use of for paving stables, lobbies, and halls, here, as well as in England, where Windsor Castle carriage-way is so paved. There are a multitude of uses for the material, such as baths, dishes for photograph and chemical purposes, telegraph wire covers, boots, shoes, toys, life-preservers, clothing, furniture covers, travelling bags, tents, beds, water pails. It is being constantly applied to new uses, as the chemical modes of treating the article develop new properties.

The uses of the article were, however, still comparatively limited. The water-proof qualities were, to some extent, availed of, and its elasticity was ingeniously applied in many minor directions. The native article itself was still an impracticable object in the manufacture. It had baffled the philosopher, the chemist, and the artisan in investigating its nature and in controlling its properties. Repeated attempts were made to transport the pure juice or gum to Europe, there to be operated upon, but without success, since it was found that it rapidly degenerated. A method of doing this was finally devised by Mr. Lee Norris, of New York. The liquor is first filtered and mixed with ½ its own weight of ammonia. On being poured out on any smooth surface, and exposed to a temperature of 70° or 100° of heat, the ammonia, which had preserved it from the action of the atmosphere, is evaporated, and leaves the gum in the form of the object

which holds it. Its intractable nature was finally, however, conquered by Charles Goodyear, who controlled it, apparently, as Rarey does horses, viz., by producing the result without any one being able to explain the phenomenon. Mr. Goodyear spent 20 years of the most unremitting toil in experimenting upon India-rubber, and finally discovered that a mixture of sulphur, white lead, and caoutchouc, exposed to regulated temperature from 8 to 12 hours, becomes "vulcanized," or an entire new substance unlike any other. The native rubber, being exposed to the extremes of heat and cold, is destroyed; but those agencies have no effect on the same article vulcanized. The liquids which dissolve the pure rubber do not influence the new article, which, however, acquires a far higher degree of elasticity — becomes, in fact, an "elastic metal." The article, when put into the heaters, is a tough, sticky, unelastic dough. It comes out endowed with a high degree of elasticity, insensible to heat, or cold, or solvents, and applicable to almost every want of life. It has been since discovered that the white lead contributes but little to the change undergone in the heaters, the cause or manner of which has baffled the skill of the most scientific chemists in this country or Europe. In mixing the proportions of the compounds, reference has always been made to the nature of the objects to be manufactured. The form and adaptation of the articles are perfected before the "vulcanizing." The general mode of preparing the rubber is the same. The rubber imported from the East Indies is said to be of a stronger fibre than that of South America, and the gum is selected in accordance with the manufacture proposed. It is imported in rude masses, in which sticks, leaves, and dirt are thickly mingled. These are about 2 feet long and 1 foot thick. The first process that the gum undergoes is the expensive and laborious one of cleaning, by which the mass loses about $\frac{1}{5}$ of its weight. A large vat is filled with hot water, and in this the rubber remains until the exterior is sufficiently softened to allow of the removal of the coarse basket-work that covers and adheres closely to it. When this is done, the lumps are, by means of a circular knife of a diameter of 4 feet, revolving with great speed under the influence of powerful machinery, cut into slabs about 1 inch thick. The engraving will give a good idea of the operation. These slabs are then carried to the "cracker," of which an illustration will be found on another page. This is formed of two large cylinders grooved longitudinally, and revolving slowly but irresistibly. Between these the slabs, as they are passed, are elongated and twisted, by which operation much of the dirt and bark works out. The stretched slabs are then taken to the washing machine, where numerous sharp knives, revolving under the water, cut it into small pieces, as seen in the baskets on the right of the illustration, which, at the same time, are kneaded and washed until they are thoroughly cleansed. They are then ready for the grinding machine. This consists of large hollow cylinders, made of cast iron, and revolving in opposite directions. The small pieces that come from the washing machine, being fed in, are kneaded by the cylinders again into thick sheets or mats. With this process the preparation is suspended for several months in order to allow the mats to be thoroughly dried and cured by the action of the air. This involves the necessity of keeping on hand a large stock of rubber.

When the rubber is quite cured, it is taken to the mixing machines, where it is to be combined with the various metals and substances to which the metallic rubber owes its peculiar properties. The mixing machines, like most of those used in the manufacture, are hollow revolving cylinders. The mixing cylinders are of great size and strength, and acquire the necessary heat to work the rubber from the steam let in at the ends. These, revolving toward each other, knead the rubber like dough. In the process, a constant series of explosions, like pistol-shots, is caused by the air confined in the folds of the substance being forced out by the action of the cylinders. This, on a grand scale, repeats the boy's amusement of chewing rubber soft in order to explode on his fist the air-bubbles created in it. As the rubber softens under this action, the workman slowly mixes in the various substances required. These consist mostly of sulphur, to which are added the oxides of various metals, zinc, lead, iron, etc. Here the greatest skill of the manufacturer is brought into requisition. Every quality of rubber requires a different compound, and every difference in the compound requires a different treatment in the subsequent stages of the manufacture. Thus prepared, the substance is ready to be moulded and shaped into the various forms

in which it is to be finally perfected and used. The modes of preparation are various, according to the ultimate object—whether that may be for it to assume the form of the hard, unelastic comb, a door spring, a steam valve, a carpet, or any of the thousand shapes it is made to take.

It may be here remarked that the discovery, great as it was, was but the first step in the great series of improvements that has resulted from it. After 18 years of incessant labor, Mr. Goodyear had perfected a raw material—but a raw material for what? It was necessary to know to what articles it could be applied before there could be any demand for it; until then it was of no marketable value. It was necessary to invent or discover all the uses to which it might be applied. The shoe business was the first to make it available; but since then, vast as has been the number of manufactures based on it, discoveries are being daily made to extend it.

The manufacture of "belting" and "hose" is a very large business. The belts are used for driving machinery, and are superior to every other means. They are stronger than the best sole leather, and adhere to the drum or pulley with a tenacity that prevents slipping. This manufacture is a peculiar process. Cotton duck, similar to that of which sails are made, is woven in a mode to give double the usual strength longitudinally. This duck is impregnated with the rubber, under the influence of powerful machinery, which drives the substance through and through its meshes. It is then taken to the calender machine, seen in the engraving. The large cylinders of which it is composed have a perfectly polished surface. The rubber having gone through the mixing process, is in the shape of sticky, slate-colored dough, and passing through the calenders, is rolled out into a perfectly even sheet, upon the prepared duck. When this is completed, the "bolts" are taken to the belt-room, spread out upon tables 100 feet long, and cut into the strips desired for the various kinds of belting. For one of great strength, several of the strips are placed one upon the other, and then pressed together with immense power, by rolling-machines; thus giving them the strength of metal, with the peculiar friction surface found only in rubber. The belts are now ready for the heaters. These are long steam boilers, the door of which being opened, there is drawn out a long railway carriage. On this are placed the goods, which are then rolled in, the boiler closed, and steam admitted. In from 8 to 12 hours, the singular transformation known as vulcanizing, takes place.

The manufacture of "Croton hose" is similar. A long iron tube, of the proper diameter (and hose is made from ¼ inch to 12 inches) is covered with a sheet of carefully-prepared rubber. This, however, intended to be pliable, would not of itself be of sufficient strength to sustain a strong head of water, hence it is covered with webs of cloth prepared in the manner of the belting duck. When a sufficient number of folds have been applied to give the required strength, an outside covering of pure rubber is applied. A heater of immense length then receives the pipes, with the hose on them, to be cured by the same process as the belts. The hose is then drawn off the pipe to be subjected to proof. This hose will withstand a pressure that will burst the most powerful leather hose.

One of the most useful applications of vulcanized India-rubber, is steam packing. The vulcanized rubber is the only material that will preserve its elasticity and counteract the expansion and contraction of metals exposed to the heat of steam, thus making a joint perfectly steam-tight. It is used to pack round piston rods in steam machines; to place between the iron plates of steam pipes, wherever a joint is required; for gaskets, valves, and rings. Some ocean steamers have huge rubber valves, five feet in diameter, which play up and down in the vast cylinder, opening and shutting like the valves of a colossal artery. The use of rubber is now so great a necessity, wherever steam is used, that the mind wonders how it could ever have been dispensed with. It is not only steam, however, but every branch of mechanics that demands its presence, in the shape of sheets, plates, rings, hollow ellipses, of all imaginable forms and sizes, of which none but a mechanic can conceive the number applicable to his own art.

The use of rubber for car-springs has become almost universal. The high degree of elasticity which the sulphur imparts, makes that application an admirable one, and the more so that it does not lose the elasticity by prolonged use.

The "elastic metal" supplants the rigid one in numberless uses. House-sinks, in-

stead of cast iron, are now formed of rubber, without joint or seam; and these are far less fatal to the china washed in them, than were the metal ones. Springs for doors, from this material, supplant all others. These, for churches, are so arranged that the door may be closed, or held open to a desired distance. For bed-springs, it has become the most desirable, durable, and luxurious material. Carpets and mats for halls, stairways, and public rooms, are formed of it, of infinite variety and usefulness. The mixture of lead in the compound was found to make it more compact and heavy, but the peculiar properties are apparently attained as well without the use of the lead. The combination with sulphur has been effected by exposing the material to the action of sulphurous fluids, as the sulphuret of carbon and the chloride of sulphur. An immersion of one or two minutes, in a mixture composed of 40 parts of sulphuret of carbon to 1 of chloride of sulphur, kept at the usual high heat, will produce the vulcanization; and pressed into moulds while at the high heat, the form becomes permament when cold. For the purpose of imparting that hardness which is manifest in combs, fancy boxes, canes, buttons, knife-handles, and all those forms in which it has supplanted bone, shell, and ivory, magnesia is introduced. It is stated that sulphur, in the proportion of one to three, will impart the hardness if the high temperature is sustained for a sufficient length of time. The magnesia gives a lighter color to the articles in which it is compounded. In the manufacture, articles to be heated are buried in pulverized soapstone, by the introduction of highly heated steam. The ingenuity of chemists and mechanics is still actively stimulated to produce new compositions and new results, not only in the properties that result from new compounds and varied proportions, but in the applications of which they are susceptible. Vast as are the resources that rubber opens to the arts and to trade, it may be said yet to be in its infancy. The effect upon the commerce of the country is seen in the following table. The largest proportion of caoutchouc used in the world comes from South America.

	Rubber	Shoes exported.		Other	Total
Years.	imported.	Pairs.	Value.	rubber goods.	value.
1856..	$1,143,372	625,220	$427,936	$665,602	$1,093,538
1857..	1,012,643	537,238	331,125	312,387	643,512
1858..	755,828	247,380	115,981	197,448	313,379

There have been great vicissitudes in the manufacture of goods under Goodyear's patents. Numbers of companies have been formed in Connecticut, New York, Newark, New Brunswick, Millstone, N. J., and elsewhere. Some of these have been highly successful, and others have sunk their capitals. These companies now have a common agency for the sale of their goods, under certain regulations and restrictions, by which the ruinous effects of competition are abolished. The market is supplied, and not overstocked, each manufacturer having his proportion of the aggregate sales. The companies, however, in face of a large decline, as seen above, in the export of shoes, arising from the progress of the manufacture in France and England, raised the prices of the goods last year, and this had an injurious effect upon the business. The extension of the use of rubber is, however, still progressing, and there is yet hardly a limit to be assigned to the future usefulness of the article.

Gutta percha is used extensively for similar purposes as the caoutchouc, and is prepared in the same manner by Goodyear's process. It is a gum found in the trees of the Malay peninsula, and procured in the same manner as caoutchouc. European attention was first called to it in 1842, and it began to be imported in 1844. Its chemical composition is identical with that of India-rubber, except that it contains oxygen, which rubber does not. It has a number of qualities that make it preferable for certain uses. It is a bad conductor, and is therefore very applicable as a covering for telegraph wires, and its peculiar acoustic properties make it valuable for speaking-tubes in public houses and large establishments. The application of gutta percha to the coating of telegraph wires is claimed by Mr. Samuel J. Armstrong, of New York, who for that purpose modified the machinery for gutta percha tubing. The first machinery built for that purpose was in 1848, and the first wire so coated was laid across the Hudson river, at Fort Lee, in August, 1849, for the Morse Telegraph Company. This machinery was furtively carried to England, and there used for the Atlantic Telegraph. The articles made of gutta percha alone, or mixed with other substances, are of very great variety—ornaments, vessels, articles of clothing, fancy articles, surgical articles, dentists' and numerous other articles. Vessels have also been made of it, and its uses are being daily multiplied.

PAST.

PRESENT.

SEWING MACHINES.

The description of labor which is the most general, is probably that of sewing, since all women take part, more or less, in it, and they are aided in the heavier work by men. All human clothing, bedding, upholstery, etc., have more or less sewing connected with them, and during the present century not only have the numbers of the people greatly increased, but cotton has been added as a material, to the flax and wool previously in general use. Machines have turned out cloth from all these materials in greater perfection, and at constantly sinking prices. While the individual wealth of the people has given them the means of consuming a greater variety and quantity of clothing, all of which was required to pass through the hands of female sewers, competition had among these reduced the rates of work to such prices as would scarcely afford existence. The condition of sewing women was a matter of public sympathy, and much sentiment was exercised over those who

> "Sewed, with a double thread,
> A shroud as well as a shirt."

When the inventive genius of the age was directed to the means of facilitating all labors, it is not to be supposed that this vast field could have been neglected. The attempts to invent sewing machines were many, but the most successful obtained a patent only in 1841. This does not appear, however, ever to have come into use. In 1842, another patent was issued to Greenough, and this seems to have met with the fate of its predecessor. From that time to the present, there have been 750 applications for patents, and of these, 450 have been granted. Yet the ground seems not to have been covered, since improvements continue to be very numerous. The first really practical sewing machine was that of Elias Howe, jr., patented September 10, 1846. This patent covers the formation of a seam for uniting pieces of cloth by the combined action of an eye-pointed needle and shuttle, or their equivalent, interlocking two threads. By this operation, a seam is formed by so-called "lock-stitches," of which the following is an illustration:—

This stitch is formed with two threads, one upon each surface of the fabric, sewed and interlocked with each other in the centre of it. To form this stitch, from two and one half to three yards of thread are required for one yard of seam, the quantity of

course varying slightly with the thickness of the fabric sewed. It forms an elastic seam that cannot be ravelled, and presents the same appearance upon each surface, a single line of thread extending from stitch to stitch. In formation, it closely resembles the interlocking of threads in weaving; and, indeed, the seam is an additional interweaving of two threads with the fabric sewed. A stitch of this character commends itself, especially for sewing *woven* fabrics, and if the seam be made of thread of suitable strength, is as strong and elastic as the fabric sewed. Mr. Howe's preference for the "*lock-stitch*" has been confirmed by experience, it having been used for fourteen years, in sewing every species of fabric, from the heaviest harness and upholstery to the lightest gossamer, with unqualified satisfaction.

The operation of Mr. Howe's machine was substantially as follows:—

A threaded, eye-pointed, curved needle, was thrust through the fabric to be sewed, by the action of the needle arm. Through the loop of thread thus thrust through the fabric, a shuttle passed, carrying the lower thread upon a small bobbin within it. The shuttle having passed through the loop and left therein a line of thread, the needle was withdrawn from the fabric, and the interlocked points of the two threads were drawn into the fabric. The shuttle was then returned to its starting-point, the needle again thrust through the fabric, and another stitch taken. The flow of the two threads from the bobbins was controlled by mechanical devices, constituting the *tension*.

The pieces of fabric to be sewed were suspended upon points of a baster plate, with proper holding surfaces, which was moved forward, and the length of the stitch regulated by a ratchet wheel. When a *reach* of seam had been sewed the length of the baster plate; the cloth was detached, the plate run back, the cloth re-attached to the points, and another reach of seam sewed. This constituted the *feeding* apparatus.

The *formation of the stitch*, the *holding and feeding of the cloth*, and the *tension of the threads*, are the elementary characteristics of the sewing machine. The use of the shuttle for making the stitch is still continued in many machines, but with many modifications and improvements. The method of holding and feeding the cloth is changed. The baster plate is entirely disused. The fabric to be sewed is laid horizontally upon the machine table, and is passed under a needle acting vertically instead of horizontally, as in Mr. Howe's machine. There are ingenious devices for regulating the tension of the threads, and opening the loop of the upper thread to facilitate the passage of the shuttle, so that the shuttle machines have attained a high degree of efficiency for many purposes of sewing.

The objections to them are the noisy and cumbersome machinery necessary for driving the reciprocating shuttle; the loss of power always arising from a reciprocating motion; and their inadaptability to fine work.

As is the case with most inventions, Mr. Howe's claims were disputed. It was claimed that Fisher & Gibbons of England invented the lock-stitch before Mr. Howe. It turned out, however, that Mr. Howe had perfected his machine two months before the announcement of the English patent. In 1854, the question came before the United States Court in Massachusetts. Judge Sprague in his opinion states, "There is no evidence in the case that leaves a shadow of doubt that for all the benefit conferred upon the public by the introduction of a sewing machine, the public are indebted to Mr. Howe." His claims being thus made good, those who manufactured machines covered by his patent, did so under license from him. The progress of invention has since brought three classes of machines into use. These may be stated as follows:—

1st. Single-thread or chain-stitch machines. This stitch will unravel, a fact which recommends it for some kinds of family sewing, such as children's dresses with tucks, etc., where frequent alterations are made. Of this description are Clark's, Gibbs', Watson's, Robertson's, and others.

2d. The double-thread lock-stitch founded on Howe's shuttle movement. These are of the greatest number, and are made by Wheeler & Wilson, Weed, Singer, Ladd & Webster, Finkle & Lyon, etc.

3d. The two-thread double chain-stitch is strong, and is in some respects preferred to the lock-stitch of Grover & Baker.

The sewing machine patented by Mr. Howe exhibited but little more than a combination and application of mechanical devices already in common use, although it is due to him to state that he had no opportunity of knowing what had been previously

WHEELER & WILSON'S SEWING MACHINE.

Fig. 1.—View of the Machine ready for work.

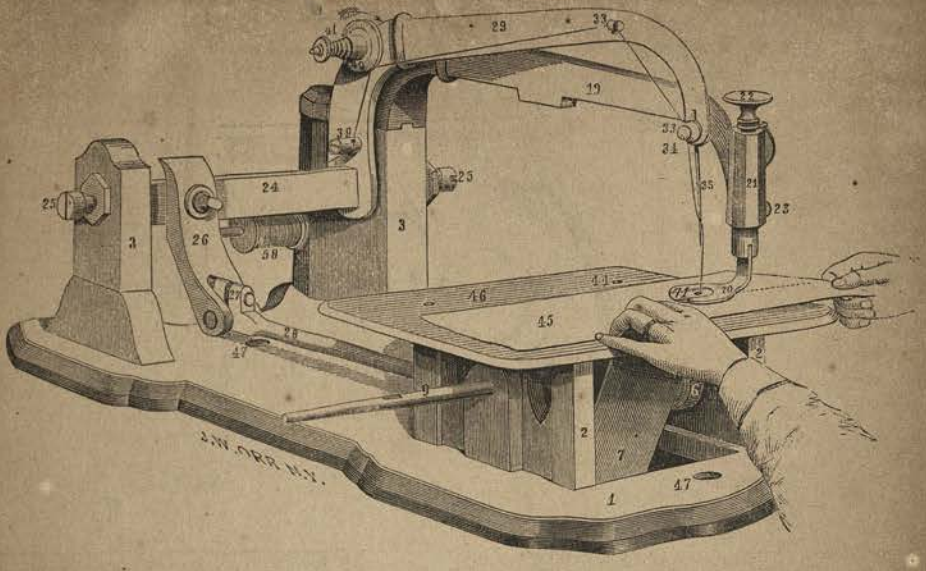


Fig. 3.—Front view of Fig. 2.

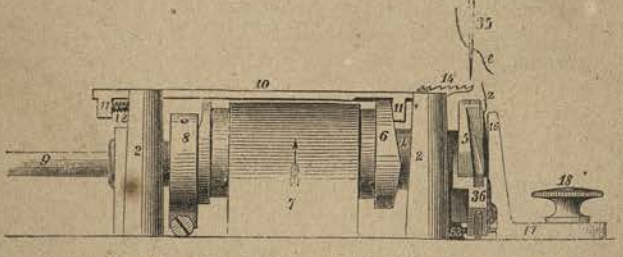


Fig. 2.—View of the Machine with the Cloth Plate removed.

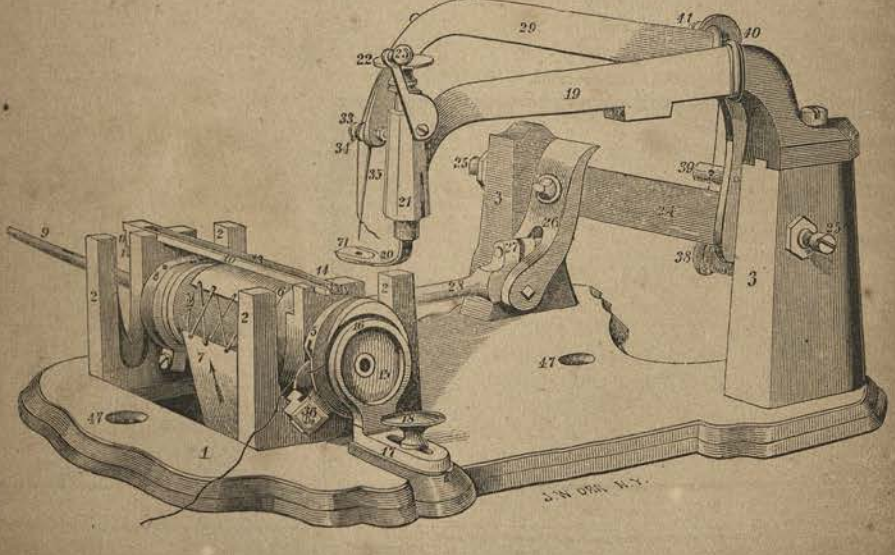


Fig. 4.

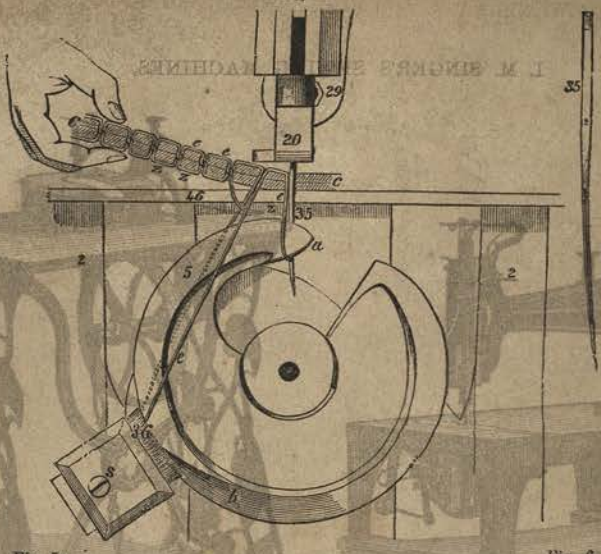


Fig. 5.

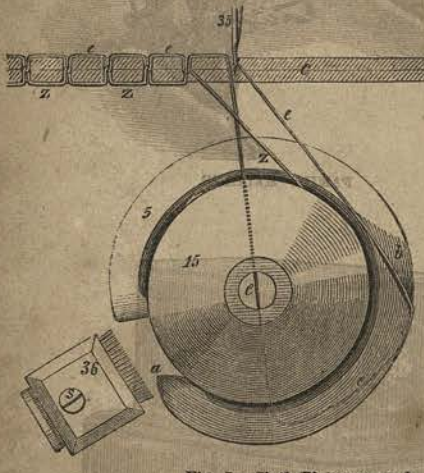


Fig. 6.

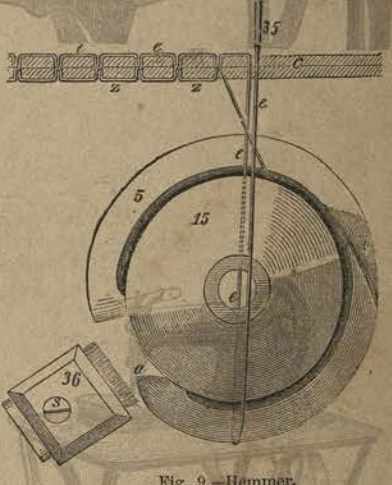


Fig. 7.—Cloth Plate reversed.

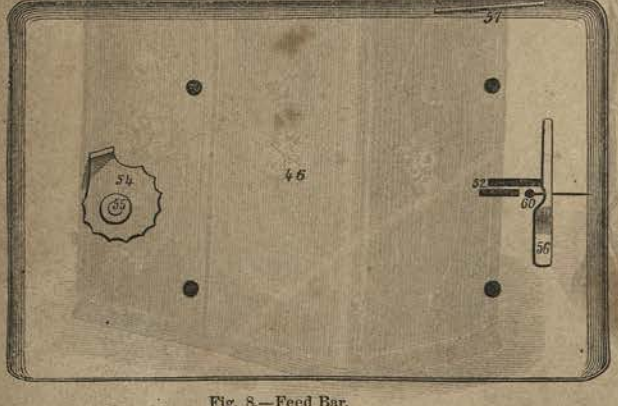


Fig. 8.—Feed Bar.

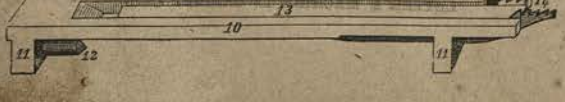
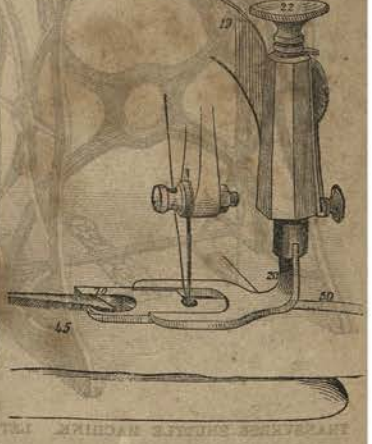


Fig. 9.—Hammer.



I. M. SINGER'S SEWING MACHINES.

No. 2.

FAMILY MACHINE.

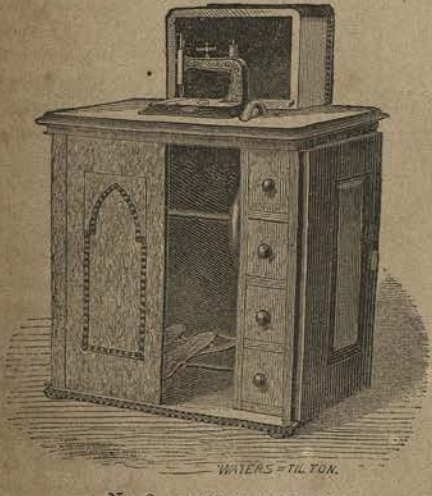
TRANSVERSE SHUTTLE MACHINE. LETTER A.

LETTER A MACHINE IN CABINET CASE.

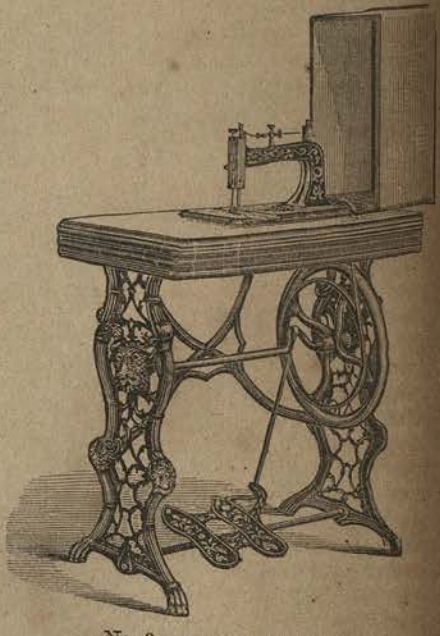
FINKLE & LYON SEWING MACHINE CO.

No. 4. LARGE MANUFACTURING MACHINE.

No longer is wrought the *gusset and band*
With ceaseless stitch and wearied hand;
For sewing is *pleasure* by magic art,
Since curious machines well play their part.



No. 2. FAMILY MACHINE.



No. 3. MEDIUM MACHINE.

attempted in regard to sewing by machinery. Among the first as an improver of sewing mechanism, for originality of conception and directness of purpose, ranks Mr. Allen B. Wilson, of the Wheeler & Wilson Sewing Machine Company. He did not follow the beaten track, but sought by original, direct, and simple methods to attain superior results. In his hands the sewing machine underwent radical changes, and his results embody mechanical conceptions that place the sewing machine among the most ingenious and effective pieces of modern machinery.

Mr. Wilson, like Mr. Howe, approved of the *lock-stitch* only, but his *method of making* it, the *holding and feeding mechanism*, and the *tension* of the threads, are radically different. Instead of passing a bobbin with the lower thread through a loop of the upper, he puts a loop of the upper around a stationary bobbin containing the lower thread, feeds the fabric to sew an endless seam, and obviates in a great measure any attention to the tension of one of the threads.

For carrying the loop of the upper thread around the bobbin containing the lower thread, Mr. Wilson employed a rotating hook of peculiar construction, marked 5, fig. 4. It is formed by cutting away a portion of the periphery of the circular concave disk. *a* (fig. 4) is the point of the hook. From *a* is a diagonal groove across the periphery of the hook to the point *b*, where the edge is bevelled off. The hook thus constitutes a portion of the thread of a screw. 46 is the cloth-plate, 35 the needle, with the eye near the point threaded with *e*, a loop of which has just been entered by the point of the hook *a*. The lower thread is carried in a double convex metallic bobbin 15, to lie in the cavity of the hook, and held in its position by a concave ring 16 (fig. 2), between which and the concave surface of the disk it lies. No axis supports it, so that a loop of thread can pass around it as the girl passes the skipping-rope under her feet.

Fig. 5 represents the hook as having made about two thirds of a revolution, and the lower thread, *z*, extending from the lower surface of the fabric to the bobbin in the concavity of the hook. The upper thread, *e*, extends through the fabric from a previous stitch into the concavity of the hook behind the bobbin, diagonally around the hook at the point *b*, thence diagonally along the groove to the needle 35.

As the hook further revolves to the position indicated in fig. 6, both lines of the loop *e* are upon the same side of the disk. The line of thread that extended in fig. 5 along the groove of the hook by *b*, has slipped off at the termination of this groove, and fallen in front of the bobbin, so that the loop of the thread *e* extends behind the bobbin, around the point of the hook *a*, and across the front of the bobbin to the needle 35, thus surrounding the bobbin, and inclosing the lower thread *z*.

As the hook further revolves the loop is held by the check 36, until the point of the hook enters the succeeding loop as seen in fig. 4, when the loop *e* is freed from the check, and being drawn up by the enlargement of the succeeding loop, interlocks with the lower thread *z* in the fabric, and forms a stitch.

This is substantially the method of forming the stitch, and it will be seen that this rotating hook is of singularly novel, simple, and ingenious construction, and is equivalent to several elaborate pieces of machinery performing the three operations of enlarging the loop of the upper thread, passing it around the bobbin, carrying the lower thread, and tightening the preceding loop.

In this connection we will explain the "*tension*." In the "*lock-stitch*," when properly formed, the interlocking of the two threads is in the centre of the fabric sewed. For this purpose the "tension" or strain upon each thread must be properly adjusted, a point of much difficulty where the thread is used from the original spools, on account of the irregularity with which they are made and the thread wound. Mr. Wilson overcame this difficulty in a very happy manner.

The lower thread is re-wound upon the metal spool or bobbin 15, of such size as to hold 50 or 60 yards of No. 80 cotton. This re-winding is effected by the machine itself, and with such facility, that less than a minute is required for re-winding a spool. The bobbin with the lower thread is placed in the concavity of the hook, and held in place by the ring 16 (fig. 2), with the thread flowing from the top toward the front of the machine, in which direction it revolves slowly. The hook 5 revolves rapidly in the opposite direction, and the friction between these surfaces renders the strain or tension

upon the lower thread sufficiently great to keep it straight.

The upper thread is fed from the original spool 38 (fig. 1), through the guide 39, passes once around the tension pulley 40, and thence through the eyelets 33, 33, and the needle 35 near its point. Its flow is regulated by the thumb-screw and volute-spring 41 pressing against the side of this pulley. Should the thread be drawn too easily from spool 38, the hook will draw thread from that instead of drawing up the preceding loop (fig. 4). The proper pressure, however, being upon the pulley 40, the hook draws up the previous loop to the proper position of interlocking in the fabric, before it draws any from spool 38. From this it may be seen that the tension of the lower thread is automatic, and requires no care, and attention is only paid to the tension of the upper thread, which is readily effected by the thumb-screw 41.

The feeding mechanism of Mr. Wilson's invention consists of a feed-bar 10 (fig. 8), slatted nearly its entire length, in which is pivoted near the left end the feed-tongue 13, armed with two rows of feed-points, 14. This feed-bar works in grooves in the standards 2, 2 (fig. 3), and lies just beneath the cloth-plate 46 (fig. 1), so that the points 14 may be raised through the slots 52 (fig. 7), with its left end against the feed-stop 54. The feed is worked by a cam 6 (fig. 3), which rotates with the arbor 4. As this cam revolves, the swell of its periphery strikes the under surface of the feed-tongue 13, and raises the feed-points 14, through the slots 52, while the swell upon the right side of the cam 6 presses upon the right ear 11 of the feed-bar, and throws it forward. The cam further revolving, brings a point of depression both in its top and its side next to the feed-bar ear, when the points drop below the surface of the cloth-plate and the feed-spring 12 (fig. 3), working between the left standard 2, and the left ear 11 of the feed-bar, throws the bar back to the left against the feed-stop 54 (fig. 7), and the next revolution of the cam throws it forward. It should be remarked that while the needle penetrates the cloth, the feed-points are below the surface of the cloth-plate, and intermit their action upon the cloth; hence the needle constitutes a pivot upon which the fabric may be turned to sew a curved seam of any radius.

The feed-points rising and penetrating the cloth at each stitch, their movement forward determines the length of the stitch, which is graduated by regulating the play of the feed-bar. The play of this bar is limited to the difference between the widest and the narrowest parts of the feed-cam 6, which is about one fourth of an inch, and may be graduated to any length within those limits, by the feed-stop 54, against which the feed-bar is thrown by the feed-spring 12. As the widest or the narrowest part of this eccentric stop is turned toward the feed-bar, greater or less play is permitted, and longer or shorter stitches are made. This stop is turned with great facility while the machine is in motion by the point upon it.

The machine is mounted upon a neat work-table, as seen in the cut at the head of this article, and driven by sandal treadles and band 7 (fig. 1). Motion is thus communicated to the hook 5 (fig. 2), and by the eccentric 8 through the connecting-rod 28 to the rocker 24, pivoted at 25, 25, and gives motion to the needle-arm 29, which holds the needle 35. The needle vibrates through a small hole 60 in the cloth-plate. The threads being adjusted, the machine is touched into motion by a gentle pressure of the foot upon the sandals. The cloth moves forward from left to right, and the sewing is accomplished in the manner described. The driving-wheel is graduated ordinarily so as to make five stitches at each tread. When driven by power, 1500 or 2000 stitches per minute are made through the day. The bearings and friction surfaces are so slight that the propelling power required is merely nominal. The rotating-hook, feed, bobbin, and other parts at all subject to wear, are made of finely tempered steel; the other parts of the machine are tastefully ornamented, or heavily silver-plated. The various parts of the machine are made by machinery, and thousands of pieces are precisely similar, and fit each of all the machines.

This machine is adapted to family work, and to manufacture in the same range of purpose and material. It works equally well upon silk, linen, woollen, and cotton goods—seaming, quilting, gathering, hemming and felling—performing every species of sewing except making button-holes, stitching on buttons, and the like.

Various appliances are furnished for regulating the width of hems, etc., until the hand and eye have become trained to dis-

pense with them. Another appliance is the hemmer by Chapin (fig. 9). It is slipped into a slot of the cloth-presser 20, and is so convoluted, that as the edge of cloth passes through to be sewed, it is turned down as in ordinary hems, and beautifully stitched. Hems of any width are turned. Other appliances are furnished for special purposes.

The machines of I. M. Singer & Co., having been the first in the field, acquired a prestige which they have since retained in the whole field of clothing industry. As that branch of manufacture was that which was most obviously to be benefited by the invention, the efforts of the patentees to extend the knowledge of it were more particularly urged in that direction, and it has been pushed with extraordinary business vigor. In all the leading cities of the Union there are sale agencies that have become the centres of large circles of trade. The origin and progress of the Singer machine manufacture, forcibly illustrates the extraordinary success that sometimes attends the introduction of serviceable inventions. I. M. Singer in the year 1847, being then the inventor of a machine for carving wood, suffered a ruinous disaster by the memorable and heart-rending steam explosion in Hague street, New York. Thus thrown out of business, he turned his attention to the principle of sewing as then developed by Walter Hunt, whom he ever regarded as the true inventor of the sewing machine. In acknowledgment of the benefit he had derived from Mr. Hunt's labors, he paid him an annuity for many years, and continued it to his family after his death. Pursuing the idea of Hunt, Mr. Singer perfected a machine, September, 1850. So destitute was he of resources, however, that he in Boston associated himself with Mr. C. C. Phelps, who agreed to do the mechanical work in the construction of a machine if the stock could be furnished. This required a cash capital of $40, that was finally furnished by Mr. G. B. Zieber, a book agent, on the condition that all three should share equally in the patent to be taken out. It resulted, however, that before the end of the year, Singer found means to buy out Phelps for $4000, and in 1852, Zieber sold his interest to Mr. Clark, who remains, with Mr. Singer, joint proprietor of the patent. It may be here remarked in passing, that Mr. Zieber is now the Rio Janeiro agent for Singer & Co.

The machine thus produced by Singer & Co. works with the eye-pointed needle and shuttle movement, of which the courts have decided Mr. Elias Howe, jr., to be the patentee. The details of the machine do not differ greatly from that of Wheeler & Wilson, with the exception that the shuttle movement is reciprocal instead of rotary. The energy with which the diffusion of the machines has been pushed, has done much to make them known, and to elicit the numerous improvements that have in the last few years been added to them. The demand for the machines following the growing acquaintance of the public with their usefulness, soon took such proportions as to require that systemization in their construction which has become so important an element in all branches of manufacture. By an intelligent subdivision and classification of the necessary labor, not only is perfection approximated, but cost of production diminished.

In a Singer machine as it at present exists, there are some 150 separate parts, each of which requires to be manufactured before all are combined in the beautiful instrument which accomplishes sewing with such speed and perfection. Where a number, say 10,000 sewing machines are to be manufactured, there must be first made 10,000 of each of the 150 separate parts that compose it; the manufacture of each one of them, therefore, becomes an important industry, and involves the invention and application of machines calculated to perfect it at small cost. There are, therefore, 150 different manufactures carried on as the elements of the ultimate whole. The larger portions of the machines are of cast iron, of which a little over 100 lbs. is used upon each. In the first years of the manufacture, these castings were made in different foundries according to patterns furnished, and they were then finished and put together in Singer & Co.'s shop. The price paid for the castings was three cents per lb., and the payments under the growing trade rose from a few dollars to about $2000 per month, which quantity of castings would suffice for 540 machines. It then became necessary to concentrate this business in one large factory, in order to economize the cost with a view to the reduction in the prices at which the machines might be sold. Therefore in 1857 Messrs. Singer & Co. purchased in Mott street, New York, between Broome and Spring streets, four lots, making a plot of ground about 100 feet square; on this they

erected an iron fire-proof building, six stories high. This was designed for casting, and for every branch of the manufacture of the complete machine. In the basement was erected a furnace which was then supposed capable of turning out all the castings that might be required. Here also is one of the most approved steam engines of 80 horse power, which, connected with every floor, supplies needful power to every worker, and is applicable to every labor. During the time that the building was in process of construction, the demand for machines spread so fast, that when ready for occupation, July, 1858, it was found that the business had already outgrown the building, and that another one was consequently necessary. The proprietors, therefore, purchased 14 lots more on Delancey and Tompkins streets, for the erection of a five story building, devoted to the uses of the furnace and castings, by which arrangement the Mott street building was reserved for adjusting and finishing the machines.

The principal parts of a machine are of cast iron, consequently that material figures largely in their construction. The quantity contained in each machine is about 100 lbs., having been considerably reduced from what it was; the needle-arm it was found might be beneficially reduced from 50 to 35 lbs. To manufacture 400 machines per week, therefore, requires 20 tons of pig iron; the quality used is of the best Scotch metal. For every part of the machine there is made in one department of the Mott street building a pattern in wood. From this is made a casting, which being highly finished and polished, becomes the standard pattern for all subsequent castings. Each of the several sizes of sewing machines requires a set of these patterns, and with these models the foundry in Delancey street works up daily three to four tons of the raw iron. The castings are then all carried to the basement of the Mott street building, where they are assorted and arranged. In the centre of the building, rising by the side of the light iron spiral staircases, is a platform, operated by steam. When the castings are ready they are placed upon this platform which carries them up to the second floor, where they undergo finishing, smoothing, boring, and other necessary operations preparatory to being brought together. The parts are here distributed each to the workman, who gives to its preparation his undivided attention. It is here that are in full play those inventions and appliances that have been found necessary in the production and finishing of all the parts of the machines; as the sewing machine itself is but a means of simplifying the labor of sewing by hand, so are numerous other contrivances put in requisition to reduce the labor of making quantities of these machines. Accordingly, as we land from the staircase in the centre of this floor of a quarter of an acre in extent, we are greeted with the click and clang and hum of cutters, trip-hammer, drills, pressers, etc., of every variety of machine for cutting, turning, boring, planing, polishing, animated by the ceaseless efforts of that noiseless but resistless giant in the basement. Each of these machines is operating upon some separate portion of the great object of all their efforts; the supports, the needle-arm, the wheels, the gearing, the feeders, the shuttle and its race, the screws, the hinges, the treadle, and so on through the whole list, are undergoing not only preparation but preparation in quantities. Thus, the iron groove called the "race," in which the shuttle moves, and which comes like all castings from the foundry in a rough state, must be brought to the proper degree of smoothness to receive the beautiful polished steel shuttle. To operate upon each race by hand, would be laborious and expensive, but some thirty of these are confined upon the iron bed of a machine, in such a manner as to present a continuous groove, through which moves with moderate speed but irresistible force the steel instrument which shaves the solid iron to a smooth surface. Thus in a comparatively few minutes are perfected the races of thirty machines, all being brought to exactly the same size and degree of polish. At the same time another machine presses red hot steel plates into the form of the little shuttles which, highly polished, fit exactly in these races. In a similar manner all the parts of the sewing machine are, by different workmen, subjected to the action of various machines, which reduce, in quantities, all to the exact appropriate form and dimensions. Even the hinges for the box casings are produced in quantities. A powerful machine stamps out the hinge from the yellow metal. The pieces thus stamped out require to be folded over in order to form the hole to admit the connecting wire. This is done by a powerful machine with great rapidity. The ingenuity exhibited in the various tool machines is

wonderful. We may mention one. The possessor of a Singer's machine may observe operating together two bevelled cog-wheels, that communicate the power from the band-wheel to the machine. The circumference of each of these wheels is in the largest part about the size of a half dollar. When first shaped they appear like the bevelled head of a bolt; one of these is placed upon a machine about the size of a man's hat, when a circular saw, in circumference of the size of a silver dollar, approaches and cuts a cog in the solid metal with as much apparent ease as if in soft wood. It then recedes, when the cog-wheel turning on its axis, presents a new front which is instantly cut. The saw-dust falling into a little tin gutter, is conducted to a box for preservation. In a few minutes all the cogs being cut, the machine stops of itself, when the operator replaces the finished wheel by a fresh one, and the machine proceeds as before. The wheel thus cut is however not perfect. The cogs being rough and square, would not mesh with those of another wheel. It is therefore put in another machine similar to the first, with the exception that instead of a circular saw, there revolves against the cogs a wheel having on its circumference a groove which rounds off and polishes the cogs, stopping itself when it has completed its work. In this manner are prepared the cog-wheels for all the sewing machines. These multiplied contrivances applied to the manufacture of every component part, wonderfully reduce the amount of manual labor required to perfect any number of machines per week, and yet in the Mott street building there are constantly and actively employed 300 skilful men, who earn from $10 to $12 per week each.

In the third story the hum is softened, but the activity is no less effective, since it is applied to the smaller and more delicate portions of the work in hand. Here the little steel shuttles are polished and soldered, the bearings for the bobbins adjusted, and the needle-throats, the feed motions, the tensions, etc., etc., made. A portion of this floor is also set apart for the manufacture of the numerous tools employed in the factory; and this is an important industry.

On the fourth floor all the parts are combined in the completed machine, which has now to undergo an examination more rigid than any that awaits a scholar whose mind has been formed under the cares of multiplied teachers, since the smallest defect in the machine is fatal; all its parts must operate perfectly to produce the desired results. If the machine stands all the tests, it rises to the fifth story to be adorned. Here it is taken in charge by Mr. Penny, with his 35 artists, who design, japan, paint, gild, inlay with pearl or mosaic, or apply any style of ornament that the improving taste of the public requires.

The japanning, it may not be generally known, is simply an ashphaltum paint laid on thick. This would scarcely ever dry in the sun, but Mr. Penny has two sheet-iron rooms, in which he places the painted parts; he then raises the heat to 300°, and in 48 hours the japan is as hard as the iron itself, and of a brilliant polish. This does not however quite suit him, and he sets a hand to grain down the surface with rotten stone. It is then of a dead black surface, to which the polish is restored by friction with the hand. It is then ready for gilding or painting. The bands are then applied to the wheels, and the machines find their way to the large wareroom at the corner of Broadway and Grand, where, under the superintendence of Mr. Hopper, they are brought under the inspection of the public.

In the two factories the Messrs. Singer & Co. employ 400 hands at an average of $12 per week, making $4800 paid out weekly in wages. The 20 tons of pig iron used will cost $600; and eight lbs. of bar iron and steel to each machine, making one and a half tons, cost $150. Thus, for the iron and wages there is an expenditure of $5550 weekly, or $288,600 per annum, affording a strong and pleasing contrast to the condition of the manufacture ten years since, when $40 was with difficulty raised to build the first machine.

There are a number of adjunct inventions and manufactures that accompany the machines. One of these latter is the manufacture of colored silk cord for use in the various manufactures to which the machines are applied. This cord is made by a company in Massachusetts, who purchase the imported raw silk, and manufacture the desired quality. Cotton thread is also made in a special manner for the machines; and linen thread is imported by Singer & Co. in large quantities for the supply of customers. A large stock of all these is kept on hand. The adjunct inventions are many. One of the most important of these is the hemmer; of this there are many inventions. One of the pat-

ents, that of Chapin, was purchased by Messrs. Singer & Co. and Wheeler & Wilson, and they manufacture and apply them to the sewing machines. There are others, like that of Blake & Johnson of Massachusetts, which are adjusted so that material of any thickness can be folded to a hem of any breadth. These are purchased of the inventors by Finkle & Lyon, and other sewing machine manufacturers, by the gross and applied to their machines. There are also the cording apparatus, for ladies' skirts; the gauge for binding hats, invented by Singer & Co., which has wrought a great change in the hat business, as by its use one hat may be trimmed in a minute, while by hand 15 minutes are required; the gauge for binding cap fronts; that for quilting; a grooved foot for bag handles; presser and feed-wheel for carriage work; binding-gauges for shoes, and a variety of appliances to suit the exigencies of all employments. The machines of Messrs. Singer & Co. are of various descriptions; one of a light pattern is adapted entirely to family work; another to leather work, boots and shoes, etc.; another for carriage trimming and heavy leather sewing, etc., in which department they are extensively employed; still another is adapted to tailoring for the manufacture of clothing in all its branches. All the manufacturers of sewing machines are continually on the alert to add to the usefulness of the machine, by adapting it to the exigencies of all branches of manufacture. Mr. Singer has thus taken out 19 patents for improvements upon his original machine.

We have hitherto spoken of the "lock-stitch," as formed on Howe's principle of the eye-pointed needle and shuttle movement, showing the rotary shuttle of Wilson and the horizontal shuttle of Singer. The double-thread chain-stitch of Grover & Baker is of a different character from the lock-stitch, although also formed under Howe's patent. The lock-stitch claims to be interlocked in the centre of the cloth, being alike on both sides of the work, and leaving no thread upon the surface exposed to wear. It is objected to this stitch, that although it may be interlocked in the centre of a thick fabric, yet that cannot be the case in those articles that make up a large portion of family sewing, and of which the texture is not thicker than a thread. In such cases the lower thread must inevitably be straight upon the under surface, and being thus easily drawn out leave the seam ravelled. Also in many clothes, the fabric is more elastic than the thread, hence the whole strain coming upon the two crossed threads must cause them to give way. In respect of the chain-stitch, although it is formed on the under side of the fabric, yet each stitch is of itself fastened, and the wear or breaking of one will not cause others to ravel; its elasticity is also equal to that of any fabric. The following is a diagram of the stitch:—

This is the stitch of the Grover & Baker machine. It is formed by carrying the upper thread through the fabric by means of a vertical eye-pointed needle, where a loop is thrown out as the needle rises, which loop is entered by a circular needle, carrying the under thread, and this under thread, in its turn, throws out a loop, which is caught by the vertical needle, as it comes down again. The under thread is thus wound through and around the loop of the upper thread, tying each stitch twice, so that every one is securely fastened, and wholly independent of all the other stitches for strength, and if the seam be cut or broken at every quarter inch, the sewing must hold good while the fabric will wear. It gains its strength and elasticity from the under thread, which divides the strain between the several threads, and permits the upper thread to compress the material between the stitches, while each loop gives or yields to the force which the other stitches feel, instead of concentrating the strain upon one single point of the thread, as is the case with both the "single-thread" and the "shuttle" or "lock-stitch." When the Grover & Baker stitch is finished, with the loop drawn up, it is as exhibited in the following diagram:—

The under thread lies flat and close to the fabric, and after being washed and ironed, has the appearance of being inwrought in the substance of the material, and, when the proper thread and tension have been used, making no rougher surface than the under side of the lock-stitch. The machinery which makes this stitch is a marvel of simplicity

and ingenuity, requiring no mechanical skill to manage. Nor does it require other adjustment than a mere change of threads and needles, to adapt it to the character of the work to be sewed—coarse or fine, as the case may be. One of the lightest family machines will sew gauze laces, and all other varieties and kinds of fabrics, to and including beaver-cloth, without changing either needle, thread, or tensions; will sew each equally well, and return to either variety of work with perfect satisfaction.

The thread used in sewing is contained upon spools of 200 yards each. The Grover & Baker machine carries two of these spools, the upper thread No. 70, and the lower No. 120, and these are fed directly from the spools, not requiring to be rewound upon bobbins. Owing to the form of the stitch, the lower or fine thread requires to be one third longer than the upper. That is, a spool of 200 yards No. 70, will require 300 yards No. 120, and these 500 yards of thread will stitch 107 yards of cloth, none of the thread being wasted. In the Wilson machine, the circular bobbin holds 29 yards of thread, and consequently requires to be replenished seven times for a spool of 200 yards; owing also to the diameter of the bobbin, the loop of the needle requires to be large to allow it to pass. This and the quantity required to begin a seam, cause much waste of thread. Hence it is stated, that since Grover & Baker's stitch of itself takes more on the lower thread, 500 yards will make but 107 yards of seam, while with the other 500 yards of thread will give 166 yards of continuous seam; but when a great number of short seams are made, the waste of the latter is equal to the yards of seams. It is also stated, that the reciprocating shuttle, having the thread wound upon a long bobbin of no great diameter, when filled works with far greater regularity of tension than the circular bobbin, where the distance when full, from the axis to the circumference, is great.

The machines of Grover & Baker are susceptible of all the adjunct inventions, such as hemmers, etc., that are applied to others for all descriptions of work. In some cases of leather and carriage work, the ornamental character of the stitch when in colored silks, is a desideratum. Although there is a large building on Broadway, New York, occupied as salesrooms, the factory for the manufacture of these machines is in Boston, at the corner of Washington and Waltham streets, where a building 150 feet square contains 400 workmen, who are busily engaged in turning out about 1500 machines per month.

The machines of Finkle & Lyon have been more recently introduced into the market than those of either of the large factories that we have mentioned. They are however of singular merit, as may be illustrated in the fact that working as they do with the reciprocating shuttle, they carry a seam with the same needle and thread through almost every variety of substance without change. Thus a series of eight to ten substances, from thickest and hardest sole leather down to the lightest gauze, being laid parallel, the machine carries a seam through all with the greatest beauty and accuracy.

In these machines the shuttle is carried in a cradle, as the inventor asserts, to avoid friction in the shuttle race. The feed is the "wheel feed," operated by a toggling pawl, certain in its operation, and simple in adjustment; the tension is from a rod, around which the thread is twisted, each turn increasing the tension. A peculiarity is claimed in the operating cam. The groove in this cam, which gives motion to the needle-bar, is so arranged that the needle-bar is at no time actually at rest, but its speed, as it approaches the top or bottom of its stroke, is gradually increased or diminished. The machine works with a short needle, and the loop thrown off for the shuttle to pass through is very small; the slack of the thread is drawn up by a peculiar lever operated by the needle-bar, and seems to work with great precision. In the work done by this machine for the inspection of a committee, the operator stitched from fine gauze to thick cloth and leather without any change in the feed, needle, or tension. The machine is geared to run at a high speed, being five stitches to each revolution of the treadle crank. It runs very lightly and with but little noise. The Board of Examiners for the Philadelphia Institute ranked this machine first.

We have said that all these different styles of machines are founded upon the patent of Elias Howe, jr., which covers the eye-pointed needle and shuttle movement. The manufacturers therefore operate under license from him, for which they paid a minimum of $5 on each machine manufactured and sold up to the time of the renewal of his patent, in

1860, for seven years. At that time the sewing machine business had taken much larger proportions, and the terms of license were altered to a graduated scale by which the charge diminishes as the annual number sold increases. A certain rate is charged up to 2000 machines, and a less one for sales of 5000, and so down to a minimum of $1 each machine; at these rates the revenue becomes immense. Indicative of this is the following table of Howe's returns of the number sold during many years. It will be remarked that those makers longest in the field are they who have built up the largest business. The number sold is not therefore a positive proof of superior excellence. These aggregates for eight years amount to over 148,000 machines of the makers named; but there have been made and sold great numbers by infringers of patents, and a large number of an entirely worthless character, and which have done much to damage the reputation of sewing machines in popular estimation.

NUMBER OF SEWING MACHINES MANUFACTURED AND SOLD UNDER ELIAS HOWE JR.'S PATENT OF SEPTEMBER 10, 1846.

1853	No. of machines sold	294
1854	" " "	4,109
1855	" " "	3,515
1856	" " "	7,221
1857	" " "	12,719
1858	" " "	17,746
1859	" " "	47,169
1860	" " "	56,131
		148,904

The proportion of sales, up to and inclusive of 1859, was as follows:—

	1853.	1854.	1855.	1856.	1857.	1858.	1859.
Wheeler & Wilson	109	856	571	2,210	4,842	7,978	21,306
Grover & Baker	66	1,833	1,045	1,952	3,380	5,070	10,280
I. M. Singer & Co.	40	829	90	2,654	3,630	3,594	10,953
Ladd & Webster	16	268	73	180	453	490	1,708
A. B. Howe	..	60	53	47	187	179	921
Bartholf	35	55	31	35	31	203	747
Leavitt & Co.	28	217	52	143	196	75	213
Finkle & Lyon	..	..	..	..	..	..	..
All others	..	..	..	..	..	157	1,041
	249	4,109	3,515	7,221	12,719	17,746	47,169

The machines now in use, with their numerous appliances, are a long way in advance of the original combination of Howe, which although containing the principle that has since been so fully developed, could hardly, if at all, have been called much of an aid to industry. While these inventions were progressing, however, there were many very grave general difficulties to be overcome. The most prominent of these were the incredulity of the public, the indisposition to introduce radical changes in the mode of doing business, the trouble of teaching operatives, and the imperfect manufacture of the thread. That which would answer for hand sewing at the rate of 20 to 30 stitches per minute, would by no means do for a machine running 1500 per minute. This involved the necessity for a new improvement in the making of thread, and the production of machine twist supplied that demand. This is now made to a value of $2,000,000 per annum.

The economy of the sewing machine was determined by a series of carefully conducted experiments made by the Wheeler & Wilson Sewing Machine Company. Four different makers were employed by hand, and four others with machines, in sewing each seam of a garment by hand and with the sewing machine, and noting the comparative time. Subjoined is a summary of several of the tables:—

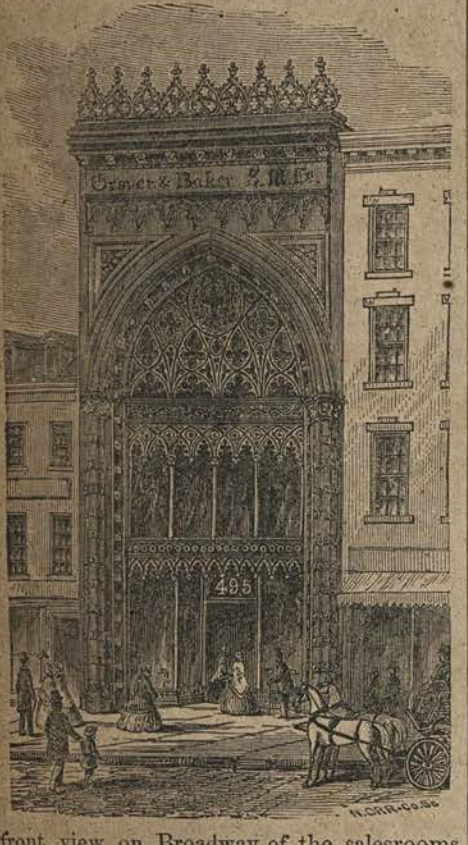
	By machine.		By hand.	
	Hours.	Min.	Hours.	Min.
Frock coats	2	38	16	35
Satin vests	1	14	7	19
Linen vests	0	48	5	14
Cloth pants	0	51	5	10
Summer pants	0	38	2	50
Silk dress	1	13	10	22
Merino dress	1	4	8	27
Calico dress	0	57	6	37
Chemise	1	1	10	31
Moreen skirt	0	35	7	28
Muslin skirt	0	30	6	31
Drawers	0	28	4	6
Night dress	1	7	10	2
Silk apron	0	15	4	16
Plain apron	0	9	1	26
Gentlemen's shirts	1	16	14	26

In sewing seams of any considerable length with the machine, one yard a minute is readily sewed.

NUMBER OF STITCHES PER MINUTE BY HAND AND WITH THE SEWING MACHINE.

	By hand.	By machine.	Ratio.
Patent leather fine stitching	7	175	26
Fitting ladies' gaiters	28	510	18
Binding hats	33	374	11
Stitching vamped shoes	10	210	21
Seaming fine cloth	38	594	16
Stitching fine linen	23	640	28
" " satin	24	520	22
" " silk	30	550	18

The warehouses for the sale of sewing machines, now quite numerous, are to be found principally on Broadway; most of the large manufacturers have there their head-quarters, wherever may be the factory or the branches. They are constructed in the newest style of warehouse splendor, and combine, in an eminent degree, ornament with convenience. The following cut represents a



front view on Broadway of the salesrooms of Grover, Baker & Co. It is situated on the western side, between Broome and Spring streets. The depth of the lower room is nearly 100 feet, and the front is almost entirely of glass, without shutters, consequently is closed at night only by locking the door. The thick plate glass, of which one forms an entire window, is not easily broken, and the protection is found in a gas light burning all night in such a manner that no movement within can be concealed from the police patrol of the streets. On this long floor, richly carpeted, the machines are displayed, and inspected by the buyers to whom instruction is imparted in the inner rooms by competent persons.

It is conceivable that, when the fact came to be clearly established that machines would do good and strong sewing, and with a speed so much greater than hand sewing, every branch of industry in which the needle is used began to introduce and adapt the machines to its own exigencies. It was soon found that some machines were better adapted than others to particular labors, but by general consent the machine of Wheeler & Wilson was considered the family machine. The clothing business, which has become so important as a new branch of industry in the last 25 years, found a powerful auxiliary in the sewing machine, and great numbers are used in it, mostly Singer's. It is to be considered, when a machine will make 1500 stitches per minute through the day, and the motive power is a girl's foot, that, how light soever may be the force required, yet the position becomes excessively tedious. Hence caloric power has been applied by the clothing houses with great success. It has been stated under the head of the clothing manufacture, that there are two branches of sewing, one done in the warehouse of the manufacturer, and the other put out to persons who take the work to their own houses. These latter are by far the most numerous. They are, however, generally poor, and although competition requires them to have each a sewing machine, they have not always the means of buying one; hence the manufacturers sell them on terms which allow the workers to pay a portion monthly until the purchase is complete. Great numbers are thus distributed. The facility of manufacturing thus brought about has also extended the clothing trade. On the occasion of the renewal of Mr. Howe's patent in 1860, it was stated in evidence before the Commissioner of Patents, by a member of one of the largest clothing establishments of New York, that the house does a business of $1,000,000

per annum; that they use 20 sewing machines in the store, and give out large quantities of work to be done on similar machines. They pay out $200,000 per annum for sewing, that by hand would cost $300,000. This house does but a small portion of all the work done in the city. The saving in that line effected by machines is estimated at several millions for the city alone. Mr. James M'Call estimated that the full employment of these machines for the clothing business of the Union would effect a saving of $75,000,000. It is to be borne in mind that while females are thus relieved from the severe labor of hand sewing, and their ability to turn out work is increased at least fourfold, yet the demand for sewing has increased in a higher ratio, and they earn more money with steadier employment than before. The greatest saving is said to be in linen coats and similar light work. In this work 50 per cent. is economized. The first introduction of the machines in New York city gave a great impulse to the clothing trade, but the machine is now travelling in all directions, following the demands for goods, and the business is becoming decentralized. A shirt manufacturer of New Haven states that his factory turns out 800 dozen shirts per week, and that he uses 400 machines, which are equal to 2000 hand sewers. The price for hand sewing was $3 per week, which would be $6000 to turn out the same quantity that 400 machine sewers now perfect at $4 each, or $1600 per week. In this ratio, the saving by machine sewing for the whole Union would be nearly $12,000,000 for that single article. The improvement effected by the machine in this department may be illustrated in the fact that ordinary shirt fronts of two plaits require 42 yards of stitching. This is done by the machine in 30 minutes, in a manner that might require 20 hours by hand; and the value of the trade is estimated at $10,000,000.

The cap manufacture of the city of New York is said to amount to 376,000 dozen annually. The price for making these by hand, was 60 cents per dozen. The machine makes them better at 10 cents per dozen. All the sewing is done except putting in the lining and the fronts. The saving on this cap business is therefore $187,500 per annum, a sum divided between the sewers and the buyers of the caps. Gentlemen's hats were formerly trimmed by hand. By the improvement of Singer's machine, a hat is now bound in one minute, when 15 minutes was formerly fast work. The number of hats bound per annum was estimated at 375,000 dozen, and the price by machine is 5 cents per dozen, against 30 cents by hand, showing a saving of $94,000.

Pocket-books and satchels being now made by machine, have so monopolized the market, that importations no longer take place.

The business of ready made cloaks and mantillas for ladies, has been of a few years' standing only, and the sewing machine was adopted for it in 1853. The effect was a considerable reduction in prices, and a great extension of the use of the garment. The amount of the business in New York is set down at $3,000,000 per annum. The immense expansion of crinoline, also, received an impulse from the use of sewing machines upon hoop-skirts. The work done on coarse goods, such as the bag manufacture, for all purposes, grain, flour, etc., is considerable. The number of these made per annum is set down at 36,000,000.

In the heavy work incident upon the boot and shoe manufacture it is estimated that one machine will do as much work as 12 hand sewers, and do stronger work. It has been estimated that the boot and shoe business of Massachusetts is worth $55,000,000 annually. Of this, one half is composed of ladies' gaiter boots and shoes, and the amount paid for labor is $250,000, mostly by sewing machines. This sum is about one fourth what the same work could be done for by hand, and the price of the shoe has consequently been very much reduced to the consumer. It is stated that 5000 machines are employed stitching boots and shoes in Essex county, Mass. They are usually owned by the operatives, who take the work to their own homes. The price per pair for sewing is one fourth the cost of hand sewing, while the sewer earns nearly three times as much per week.

The sewing required for families is also very large. A careful estimate for a comfortably provided wardrobe of a family consisting of husband, wife, and five children, is as follows:—

For the husband—One dozen shirts, with bosoms and collars; four night shirts; two pairs of under shirts and drawers; one dozen pocket and neck handkerchiefs; one

dozen pair of stockings; one morning gown; one overcoat and two dress coats; three pairs of thick pantaloons, and three thick vests, for winter; two coats, three pair of pantaloons, three vests and one overcoat, for spring and fall; and for summer, three coats, six pair of pantaloons and five vests. The wife would require one dozen dresses, of different materials; an equal number of skirts, and as many changes of under garments; one winter cloak, and various other outer garments, according to fashion; one dozen pairs of hose and gloves, besides numerous cuffs, collars, under sleeves, aprons, handkerchiefs, etc. Each of the five children would require more changes than either of the parents, because they soil them more readily, wear them more rapidly, and also outgrow some.

Bed-linen for five beds might consist of twenty pairs of sheets and blankets, twenty pairs of pillow cases and bolster covers, besides coverlets, comfortables, quilts, ticks, etc. Table and toilet linen might be set down at half a dozen table cloths, four dozen napkins, and four dozen towels. In addition to the above, there are bonnets, hoods, caps, curtains, carpets, covers, etc., that require the use of the needle in preparing them. Crochet, embroidery, and other fancy work demand attention. Some of the articles above specified do not require renewing annually, but they all need more or less repair. The scantiness of the purse must be eked out by careful stitching and darning, which renders the amount of work about equal to making the garments anew.

The facility with which the housekeeper accomplishes her sewing with the machine relieves her of her most onerous duty, and gives her time and health for the care of her family, and for the charities and amenities of life.

If the hope that every family may sooner or later have a machine to perform the drudgery of sewing not only their present clothing, but the larger quantity they will use when the labor of sewing is reduced, is realized, then it follows that 6,300,000 machines are to be made and sold. If 2000 are made and sold per week by the manufacturers, or more than double the number they sold in 1859, it will require 63 years to supply the required number, by which time the number of families, judging from the past progress of the country, will have reached 18,000,000.

There are numbers of persons who take in family sewing to do, and having prepared it, put it out to others to sew, and these obtain machines by hire, or purchase by instalments.

The improvements that are continually taking place, dilate, so to speak, the circle of machine usefulness. The cording apparatus of Blodgett & Boynton, in connection with the hemmer, brings into the scope of the machine operation all articles that require to be hemmed or corded. Parasols and umbrellas are now made by them.

One of the last and most striking improvements in the sewing machine is that made by G. B. Arnold of New York, whereby plaits are made and secured in an accurate and beautiful series of gathers at one operation, and with the same rapidity as ordinary stitching. There are two ways of effecting this, both patented by the above-named gentleman. One invention (patented in 1860) lies in the use of a double feed, one part of which gathers the cloth while the other feeds it along under the needle. The other invention (patented also in 1860) requires but one feed, with peculiar parts acting in combination with it. These improvements are making a considerable sensation throughout this country by adding very materially to the powers of this wonderful machine; and an agent is now abroad, instructing the artisans of Europe as to the nature of said inventions.

It was long a desideratum in the tailoring business that machines should be able to make button-holes. This has at last been effected by the patent of Vogel, which makes six different stitches, and is constructed with such simplicity that a novice may learn in a short time to work the machine with perfect facility. Button-holes can be worked with perfect ease at the rate of 100 per hour, and it makes but little noise in its movements. Some of the specimens make the stitch somewhat open, but the stitch may be regulated as in other machines, so that it shall be as close as hand work. The machine can be worked with two, three, four, or five separate threads. In working a button-hole, the cord may be carried upon the upper side or upon the lower, and work over it with the same rapidity as without it. The button-hole stitch itself is regarded as far superior to that made by hand, for the reason that it is almost as elastic as any goods it is put upon. With the same ma-

chine any class of goods could be sewed, from the finest fabrics to harness leather. The machine makes two different kinds of button-holes; one of which would be pronounced by a tailor to be a French button-hole worked by hand. By the addition of another thread a button-hole is produced which is finished upon both sides of the goods. This machine has the merit of increasing the strength of the work at the point where it presses the button. This is done, as the thread passes the corners, by bringing one stitch a little back of the other, and both closer together. A change may be made in the character of the stitch merely by changing the tension of one of the threads. It makes four embroidery stitches. By a single change of one of the tension screws, instead of putting a cord, it puts a binding upon the edge of the cloth. This cord or this binding will outwear those put on by hand. The treadle and the feed are different from those of other machines. The treadle allows a single stitch to be made, and the machine to be started again without touching the balance wheel; and the feed carries both pieces of cloth along equally.

The activity which has been imparted to the use of machines has hardly yet begun to produce its effects, since the number sold, even admitting the utmost efficiency claimed for them, has not sufficed to do more than a very small fraction of all the work required in the United States. It is stated that since 1846, 200,000 have been sold, and of these, not more than one half are now in use. Sales of a great number of imperfect machines have been made, that would not do the work promised. The mode in which they are now got up comes nearer to public expectation, and great preparations are made by the leading firms to meet the growing demand.

One factory is said to cover *four acres*, and to send out *every week* nearly 1000 machines. The proprietors of another manufactory boast of their ability to supply 170,000 machines annually, yet fully believe this immense number will be made greater to meet the demand. Making every reasonable deduction from these numbers on account of contingencies, we have no doubt that American manufacturers will be prepared to supply 200,000 sewing machines during the year 1861. That a large number of them, probably as many as from 10,000 to 20,000, will be exported to Great Britain, is certain. Yet, to meet this competition, to supply even their own market, there is not a single factory in all England which is devoted *exclusively* to the manufacture of sewing machines. The machine inventors there are apparently more taken up in fighting over their rights than in supplying the public. The people there are, however, not so ready to adopt new customs, nor so quick in learning, as the Americans.

The following statistics regarding the sewing machine trade in Great Britain and the United States, compiled from Patent Office and other reports, are probably as near an approximation to the facts as can be obtained:—

	G. Britain.	U. States.
Number of patents granted	200	450
Manufacturers	5	25
Varieties of machines	6	30
Varieties of lock-stitch machines	3	10
Machines sold weekly	100	1,500
Prices	$15 to $150	$5 to $150
Lowest price for a lock-stitch machine	$110	$45
Whole number in use	10,000	100,000

A considerable number of machines have been exported from the United States to England, but the parties using them there do not wish the fact to be made public, lest they should be sued for an infringement of the patent dated December 1, 1846, granted to W. Thomas, of London. His patent expired Dec. 1, 1860, and has not been renewed, and our manufacturers now send hundreds of machines to England. In England only one kind of lock-stitch machine is manufactured, and its lowest price is $110. In Scotland or Ireland a lock-stitch machine may be bought or imported from the United States for $55.

The future operation of the machines upon this continent it is difficult to predict. It is certain that the majority of the people have not hitherto used nearly as much light and under clothing as they would have done had the sewing been less difficult and less dear to get done. The large families are mostly among the poor, and they have little time to sew or money to pay for sewing. The machine now promises to be so simplified in form and price that the humblest homes may command as well the article as the ability to use it. The sewing of a family of five persons will require the constant labor of at least one person skilled with

the needle. One machine, doing the work of five such persons, would thus supply five families; but the family possessed of one will use five times as much work. In other words, the cloth will be in five times the demand, and partly to this circumstance may be ascribed the large manufacture of cotton in the past year. If there are, as estimated, 6,000,000 families in this country, and there are three under garments, male and female, for each individual, it would require 30 yards of stuff, without including bedding, for each family. This amounts to 180,000,000 yards of cotton cloth, worth $18,000,000, made into 90,000,000 under garments.

In the table given above of the comparative length of time required to make a garment by hand and by machine, we observe that by hand a shirt is made in 14 hours and 26 minutes, and a chemise in 10 hours and 31 minutes; the average is 12 hours. Working twelve hours per day 300 days in the year, it would require 300,000 hands to make 90,000,000 shirts. At $3 per week, the pay would be $46,800,000. The same table shows that the machine will make a garment in an hour nearly, hence that 25,000, tended by as many girls, will suffice to make the 90,000,000 garments in a year. At $50 each, the machines will cost $1,250,000, and the wages of the girls, even at $5, will reach $6,250,000. The two sums together will make $7,500,000, which, deducted from the hand wages, leaves $39,300,000 as the saving by machine labor. This calculation is based on the idea that the machines become universal and all work is done on them, an event which can happen only a long time hence. This calculation is, however, far in excess of that given above as the experience of the shirt-maker of New Haven. By his calculation, each machine saves him $11 per week in wages, or $572 per annum. In the same ratio, if there are 100,000 machines now in use, the saving would be $57,200,000 in all businesses.

It follows that the consumption of goods may be at least doubled at the money now paid. The saving introduces itself into every branch of sewed manufactures, and the consumption of all textile fabrics will increase as the use of the machines spreads. This creates an effective demand upon the manufacturers for more goods, and from these upon the labor market and the producer of the raw materials. Such a demand cannot but raise the prices of the materials and the wages of labor, and thereby cause all classes of operatives to share in the benefits bestowed by these machines. While the machines are finding their way into all industries, the number of the people is increasing, and their wealth improves in a similar proportion, so that the demand for goods grows in the triple ratio of relatively cheapest cost, larger numbers to buy, and positively greater means of all to buy.

MILLS.

The universal dependence of the human family upon bread as food, has no doubt caused that article to be aptly designated as the "staff of life." It has been made of many substances, but in the American colonies, from the earliest times, Indian corn, wheat, and rye have been the leading if not the only materials. The nations of Europe have only since comparatively recent dates used grain commonly for bread. The people of the south of France for long ages used only chestnuts and similar fruits for the purpose. In Germany, rye forms the native "black bread" made of the grain ground but unbolted. The Scotch use oatmeal and barley for bread. The English use wheat commonly, as is the case now mostly in America. Here, however, the variety and abundance of animal and other food is so great that wheaten bread enters less into the daily diet of the masses than would otherwise be the case. Whatever the grain used, however, milling is the first necessity, and the number and capacity of the mills must always be proportioned to the numbers of the people. In a country like this, where they multiply so fast, the investments in mill property must keep pace with the swelling numbers of the people. We find, therefore, in the returns of the manufacturing industry of the Union for 1850, published by order of Congress, that of the whole value produced, $1,019,106,616, by far the largest item was the products of flour and grist mills. This amounted to $136,056,736, or rather more than 13 per cent. Next to this industry, the highest production was of cottons, the most general material for clothing, and that product reached $65,501,687. The largest mill interest was in the state of New York, where the product was $33,037,021. The census

of 1840 gave the number of flour mills in the Union for that year, and if we compare the population and crop of wheat as reported, with the number of flour mills, the results are as follows:—

	Population.	Wheat raised. Bush.	No. of Flour Mills.
1840	17,069,453	84,823,272	4,364
1850	23,191,876	100,485,944	11,891

In order to get the quantity of wheat floured, it would be necessary to deduct from this production the quantity reserved for seed, and the quantity exported as grain. The result would show a diminished consumption for 1850 as compared with 1840. The crop of 1850 was, however, a short one, and was therefore not a fair representation of the national production.

From the earliest settlement of the country, flour has been an important article of export, and New York wheat early gained a reputation as well abroad as at home. During the wars of Napoleon, the valley of the Hudson furnished large supplies of flour, and milling was a very profitable business. As the settlement of the country progressed, however, the supplies of wheat became greater, and the surplus produced above the wants of the people at times exceeded the export demand, and the mill interest fluctuated. Water power was the most generally used. Mills concentrated where this was to be had advantageously in the neighborhood of good supplies of wheat. The mills of Rochester, New York, where the famous Genesee wheat is floured, are a grand example of well applied water power. The Baltimore and Richmond city mills acquired great reputation, and of late years the settlement of the western country has caused St. Louis to become the central point of a vast region, and magnificent mills are there constructed. The mills at Louisville are also on a grand scale. One of those mills, as an illustration, erected at a cost of $85,000, has four run of stones of a capacity of 1500 bushels of wheat daily. Its packing arrangements are so complete that 500 barrels may be turned out in a day without spilling a handful. The mill is situated at the falls of the Ohio, just where they dash with irresistible force through the Indiana chute. The mill-race, excavated in the solid limestone, involved a large expenditure of time and money. The wheels are constructed on a new principle, being similar to the submerged propellers used in war steamers, and working an immense upright shaft, the base of which is sunk fifteen feet in the solid rock. This shaft drives the entire machinery of the mill with irresistible power and the regularity of clock work. Almost every state abounds in valuable mill sites that furnish the power for flouring the grain of the several districts for local use. Steam plays, however, an important part as a motor for supplying flour for export. The ordinary operation of grinding has been by two millstones of some 4 to 6 inches diameter, average weight 14 cwt. The surfaces are dressed, and the lower one fixed, the upper one revolving with an immense velocity, generally 120 revolutions per minute. The wheat being fed in through an aperture, is ground between the revolving and fixed surfaces of the stones. It is obvious that the great weight of the revolving stone, the speed at which it moves, and the friction caused by the interposition of so glutinous a substance as wheat, involves the expenditure of vast power to sustain the action. A single pair of stones requires a four-horse power to keep up the required motion. In this mode of grinding between such extended surfaces, the flour does not escape so readily as desirable, and becomes somewhat deteriorated by continuous retrituration. There have been many improvements introduced in the form of mills. One of the most successful seems to have been to give the stones a conical form. In this improvement, the weight of the running stone is reduced from 14 cwt. to 1½ cwt., and it is placed beneath the fixed stone; the size of both is reduced to one third, and they have the form of a frustum of a cone. It is obvious that a mass of 14 cwt. revolving over a surface, is not susceptible of the same delicacy of adjustment as one of 1½ cwt. revolving under the fixed surface, and the miller has a much easier and more effective control over the most important portion of his operations. The conical form facilitates the discharge of the flour, and obviates the clogging and overheating of the flat stones. By a judicious combination of this mill with the dressing machine, a perfect separation of the flour from the bran is effected at the moment the grist escapes from the stones. The bran still remains in the mill, and falls by its own gravity to a second pair of stones in all respects like the first pair. Both pairs being mounted on the same spindle are impelled by the same gearing. The lower

pair complete the process, and leave nothing unconverted into flour that will add either to the weight or the quality of the loaf.

The capital invested in flour mills in the whole country was in 1850 given at $54,415,581, and the production $136,056,736. This at the average value of flour would represent 27,211,347 barrels, which would give an excess of 4,000,000 over the average consumption for the inhabitants. The number of barrels exported in that year was 1,385,448. The quantity of flour exported in 1860 was somewhat over three millions of barrels. To supply this, and the wants of a population amounting, in round numbers, to 32,000,000, the quantity floured should have been at least 35,000,000 barrels, which would give a value, at the average price of the year, of nearly $210,000,000.

MUSICAL INSTRUMENTS.

The manufacture of musical instruments in the United States has received great development step by step with the expanding prosperity of the whole people. The great number of churches in the United States as compared with those of other countries, and growing out of the voluntary system as opposed to the state establishments of other countries, has led not only to the demand for a large number of organs, but also to a more munificent provision for their construction. Organ building has therefore in all the large cities become a very important occupation. Some of them are constructed with four manuals and pedals, over sixty registers, and between three and four thousand pipes. The number with 2,000 pipes is large for church use. The American organs, in tone, action, and workmanship, are equal to the best European instruments.

The most important branch of musical instrument manufacture is perhaps that of Piano Fortes. This industry was early introduced into the United States, and it has here thriven, perhaps, more than in any other country, for the reason that, although the musical genius of the people is not fully developed, yet the general distribution of wealth and well-being has been such as to allow a large number of families to possess a piano; and in the last thirty years the demand has spread in the double ratio of increasing wealth and numbers of the people. The pianos of Chickering, of Boston, have a world-wide reputation, and numberless improvements have been introduced by the American makers. The annual production is nearly $2,000,000 in value. Melodeons and accordeons are also largely made, the former adapted to church music. The American accordeons exceed those of foreign make in the range of notes, and by the introduction of an echo attachment the tone may be produced sweet and delicate as those of a flute. Flutes, guitars, banjos, violins, are also largely made. The supplying of a standing army of citizen soldiers has been a means of causing a great demand for band and all instruments of martial music, and of nearly all descriptions. Great numbers of patents have been taken out for improvements. The number of persons employed in the manufacture of musical instruments is over 2,000, and the value produced about $4,000,000 per annum.

HUMANITARIAN AND CORRECTIVE INSTITUTIONS.

CHAPTER I.

PRISONS AND PRISON DISCIPLINE.

The idea of imprisonment, as a punishment for crime, though less than a hundred years old in this country, seems to have occurred to our law-makers sooner than to those of most of the states of Europe. In the early history of the colonies, however, the prison was seldom used, except as a place of detention for debtors, for those arrested but not yet tried, and for criminals awaiting the infliction of the death penalty. Death, under the code of most of the colonies, which was based upon that of Great Britain, was the penalty of a great number of offences, not less than a hundred and fifteen in one of the states; while for minor crimes and misdemeanors, the pillory, the stocks, whipping at the whipping-post, branding, cropping, slitting the nostrils, wearing the halter, and banishment, were the usual punishments.

Very soon after the Revolution, however, the penal code was revised in a spirit of humanity in most of the states, the number of capital offences greatly diminished, the indignities to the person either abolished or (with the exception of one or two states) greatly mitigated, and imprisonment substituted for the death penalty, as well as in a milder form for various punishments of a personal character, and for heavy fines.

The prison was not at this time by any means a model institution. The worst criminals were often herded together, and fighting, blasphemy, drunkenness, and obscenity made their dens (for really they were nothing more) perfectly hideous. Often, too, young and innocent persons, unjustly accused of crime or detained as witnesses, were compelled to endure the society of the most depraved wretches, and the young man or young woman who entered the prison with no evil habits, after a few weeks' stay there emerged with tainted morals and thoroughly educated for a life of crime. In one state (Connecticut) an old abandoned copper mine was fitted up as a convict prison, and in its dark, damp shafts and galleries, into which the light of day never penetrated, criminals were confined till in many cases its poisonous air and the dampness of its walls put an end to their existence.

Pennsylvania having been the first state in the Union to ameliorate her penal code, was also the first to attempt an improvement in her convict prisons. In 1786, the Walnut Street Prison was erected on the *solitary plan*, with thirty cells. The convicts were confined in a cell larger than that generally in use in prisons, and here they remained without work or books, or the opportunity of seeing a human face or hearing a human voice. The men who advised the adoption of this plan were really humane men, who had from motives of philanthropy urged and effected the abolition of the death penalty for many of the crimes for which it had hitherto been inflicted, but they did not understand how terrible a system of torture they were establishing, in inaugurating this *solitary plan*. To have no occupation, no recreation or relief, nothing to do but to think, think, year after year; to be deprived, too, of all communication with friends, of all religious instruction, of all opportunity of reading the Bible, or any other book, was a torture so refined and dreadful that it was deserving of being ranked with the rack, the boot, and the thumbscrew of the Inquisition.

The effects of this system of punishment in producing insanity and fatuity, though obviously to us inherent in the system itself, were attributed at first by its advocates to the limited scale on which it was tried, and certain defects in the methods of construction and arrangement; and it was insisted that if tried on a larger scale and with the modifications suggested by experience, it would be found the best plan for a

prison. The citizens of Pennsylvania have been wont to deliberate for some time on the best plan for conducting public institutions, whether corrective or humane, but when their minds have once become settled in regard to them, they have never hesitated on the ground of the expense of the measures they deemed necessary. It was so in this case. Two convict prisons were needed in the state, one to take the place of the miserably arranged and managed one at Philadelphia, the other to accommodate the convict population of the rapidly growing western counties. The latter, since known as the Western Penitentiary of Pennsylvania, was first completed. It was located at Pittsburg, and was finished and occupied in 1826. The Eastern Penitentiary, located at Cherry Hill, near Philadelphia, was not completed till 1829. Meantime, the experiment of the solitary plan had been tried, though under very unfavorable circumstances, in several other states. A narrow and miserable economy had prevented such a construction of the cells as was tolerable; and the plan of strictly solitary confinement, bad enough at the best, became utterly unendurable and was abandoned.

In Maine, one of the states which tried the experiment, the cells were in the form of pits, entered through a trap door, made of an open grate of iron, about two feet square—serving the double purpose of a door and a window. The only ventilation was through a crooked orifice in the side wall, one and a half by five inches, and all the heat they had, in a stern northern winter, was by the admission of warm air through a hole in the bottom of the cell about one inch in diameter. The cells or pits were entered by raising the trap door, putting down a ladder for the convict to descend, and then drawing up the ladder and fastening the door upon him.

The Auburn (New York) State Prison, also commenced on this system, carried it out with great rigor, in small, inadequate, and ill ventilated cells, and, as was to be expected, produced the most disastrous effects on the health and reason of the convicts subjected to it, and in 1821 it was definitively abandoned.

The New Jersey Prison, though constructed on the same plan, was better arranged, and the rigor of its régime was soon modified. At the time of erecting the two Pennsylvania penitentiaries, opportunity for observation had been afforded, and the intelligent and thoughtful friends of prison reform in the state, though not disposed to give up the idea of separating convicts from any association with each other, yet saw the necessity of some modifications of the solitary system. The changes they initiated justified the change of name they applied to the system, and both in England and this country it has since been known as the *separate* system. The expenditure for perfecting the penitentiary buildings for the purpose designed was liberal, almost lavish. Each prisoner has a cell, seven feet by seventeen, or thereabouts, of good height, and well warmed and ventilated, and supplied with water for washing, a water closet, a good bed, books, and the implements of some kind of labor. There is also an arrangement, by means of which, in case of sickness, neglect, or the want of any article, he can call his keeper to his cell. These cells are so arranged as to prevent the possibility of communication between one convict and another, or the sight of one convict by another. The convict is visited by the warden, the keeper, and the moral instructor, and is allowed to receive the visits of those who are interested in his moral and religious welfare. On the Sabbath, religious worship is conducted in the corridor, and all who have cells on that corridor can listen to it, and, if they please, join in the hymns or prayers.

The revulsion of feeling caused by the cruelty of the *solitary* system, led many of the states, and prominently among them New York and the New England states, to adopt a widely different system, first employed in this country at Auburn in 1821 (though it had previously been tried in Holland), and hence often called the *Auburn plan;* a more appropriate name would be either the *congregated* or the *silent* system, as expressive of its peculiar features.

Prisons constructed on this system have small cells, usually five by eight feet in size, with iron grated doors, arranged in tiers over each other, in which the prisoners are confined at night, at meal times, and on the Sabbath, except during short religious exercises in the chapel. Attached to the prison and within its enclosure are extensive workshops, to and from which the men are marched three times a day, keeping the lock-step, and in which they are em-

ployed during the day, their services being usually let to contractors at so much per head a day, the contractor furnishing tools and machinery, and the state, rooms, power, and the board and clothing of the convict. The prisoner is prohibited from looking up from his work, or speaking to a fellow-convict, or to his instructor (the contractor's agent) except about his work; nor is the instructor or the keeper allowed to converse with him. There is usually a sermon, and perhaps also a Sabbath School on the Sabbath, and the chaplain or moral instructor is also allowed intercourse with the prisoners during the week; and in some prisons there are libraries, and the chaplain selects and exchanges the books for the prisoners.

On one or the other of these plans, the *separate* or the *silent*, or on some attempted combination of the two, all the convict prisons of this country are organized. Neither plan is free from objections, while both have also their advantages.

The *separate* system individualizes the convict; prevents his recognition by or communication with other evil disposed persons who may be in prison at the same time; renders a large armed force of guards unnecessary, since combinations and conspiracies are impossible; makes his reformation more practicable, since he is only in communication with the good and virtuous, and is left for the most part to his own thoughts, unprompted to evil by the sight of, or association with the vicious; and he is not liable, except under extraordinary circumstances, to those severe personal punishments, by the lash, the bolt-shower-bath, bucking, etc., which are regarded as indispensable in the silent system, and consequently escapes their degrading effect. It was for many years claimed that the *separate* system induced insanity and materially shortened life; but the statistics of the Pennsylvania prisons, for a considerable term of years, as compared with the best *congregated* prisons in this country, demonstrated the error of this opinion. Insanity is much less frequent than in the Auburn or the Connecticut prisons, which have been reckoned the most favorable examples of the latter, and the percentage of deaths is also smaller.

The objections to the separate system are, the much greater cost of the prison buildings, the comparative unproductiveness of the labor of the prisoners (the result of their working alone), and the general weakening of the character of the convict, making him after his discharge rather dependent upon others for guidance than independent and self-reliant in his conduct.

The *silent* system demands a much less costly structure for its inmates, and while the *per capita* cost of their maintenance and safe keeping, owing to the greater expenditure for guards and watchmen, is about the same, the labor when well (*i. e.* economically) managed, is considerably more productive. No *separate* prison has ever yet paid its way, while some of the *congregated* prisons have done so, for a time, at least.

This fact has exerted an unwarrantable influence over the legislatures of the different states, who seem to have forgotten, or never to have realized, that the design of imprisonment was to reform as well as to punish, and only to have inquired which system would *pay* the most immediate profit to the state, without reference to its effect upon the prisoner.

The objections to the silent system are, that it deals with the men in the mass, rather than as individuals; that it is impossible under it to prevent the convicts from communicating with each other, and that from their knowledge of each other they are less likely to be reformed, inasmuch as, after their discharge, the more hardened will exert an evil influence over those who desire to reform; that conspiracies and combinations are not infrequent; that extreme severity on the part of the wardens and keepers is rendered almost inevitable, and degrading punishments are frequent; that the almost unlimited and irresponsible power, necessarily reposed in the officers, is very liable to abuse; and that the constant irritation of mind under which many of the prisoners labor, stimulated, as it often is, by their overseers or companions, is very unfavorable to reformation.

When we add, that in nearly all of the states the pardoning power is exercised with very little discretion, and often with great injustice, and that the appointment of the officers of the prisons is generally among the prizes of the successful political party, and that party services, not eminent qualifications, are the ground on which the posts are claimed, it will be evident that the system is not usually so well administered as it might be.

There are, indeed, in nearly all the states,

state prison directors, or inspectors, whose duty it is to investigate the condition of the prisons and the management of the officers, and redress any wrongs or grievances of the prisoners; but in the nature of the case they can learn but little except what the officers are disposed to have them know, and in many cases cruel and inhuman beatings, and the use of the bolt-shower-bath, one of the most terrible instruments of torture ever invented, the yoke, and other punishments worthy only of the Inquisition, fall to the lot of the unhappy prisoner, often at the mere caprice of the keeper.

In Massachusetts, and perhaps in one or two other states, the plan has recently been adopted of *commutation*, or of throwing off a certain number of days, proportioned to the length of the sentence, from its term, for each month of good conduct on the part of the prisoner. Thus a prisoner sentenced for ten years, commutes five days for each month of good behavior, and may shorten his sentence almost two years, if his conduct is uniformly good. The intention of the measure is good, but there are two serious objections to it: one, that as a reformatory measure it is of little avail, since it is often the case that the sly, cunning rogue, who is constantly on his guard, is more likely to conform to the rules, in the hope of the sooner resuming his career of wickedness, than the man who, though earnestly desirous of reformation, is passionate and sensitive to harsh treatment; and the other, that the personal prejudices or spites of the keepers will often make this an engine of punishment, to the unhappy wretch who has incurred their displeasure.

A better plan, in every respect, is that adopted in Ireland, of *intermediate prisons*. The ordinary prisons of Ireland are on the separate plan, and the prisoner sentenced to one of them for, say ten years, earns the privilege, if he will, by continuous good conduct, of being transferred at the end of six years to an intermediate prison, usually connected with some government works, where the men work in gangs; and if his conduct continues exemplary there, he is discharged at the end of a year and a half, by a *ticket of license*, allowing him to be at large, he reporting himself to the constabulary station nearest him, and being there registered, the constabulary being notified also of his having received a ticket of license, by the prison authorities. During the remainder of his sentence he is under the surveillance of the constabulary force; and if guilty of any offence against the laws, can be taken at once and remanded without trial to his first prison, to serve out the remainder of his sentence. The plan works admirably there, and would, we think, do so here if the difficulty in regard to police supervision could be obviated.

Great Britain and Germany are greatly in advance of us in the matter of prison discipline. Eminent men are devoting their whole thoughts and time to the work of devising the best means of combining punishment most effectually with reformation, and the government, wisely deeming the men worth reforming at any cost, spares no expense to carry into effect the best methods. In both countries, too, every officer, even down to the lowest subordinate, is trained for his work, and is selected for his moral worth and executive ability, and not as a reward of partisan service.

Besides the convict prison, already described, of which there is one in each state, and in the larger two or three, there is in each county (with a few exceptions where several small counties have united in supporting a district prison) a county jail, to which persons arrested on a charge of crime are committed previous to trial, in which witnesses who would be liable to abscond are detained, and persons convicted of habitual intemperance and vagrancy, petty larceny, and other crimes of a venial character, are confined. To these county jails are also committed prisoners convicted in the United States courts, in many cases, and juvenile delinquents awaiting trial or transportation to a reformatory. In most cases, there are one or more apartments destined for the confinement of those arrested on civil process, and known as the debtors' prison.

These jails, when located in the large towns, or in populous and wealthy counties, especially if recently erected, are usually built substantially on the plan of the *silent* convict prisons, but the rule of silence is not so strictly adhered to. Each prisoner has a cell to himself, but the able-bodied are employed in the day time in the workshops connected with the prison, or in other work, under the direction of the jailer or his deputy. The sentences being in the majority of cases short, and the prisoners in many instances confirmed drunkards, or otherwise

physically infirm, the labor is seldom or never sufficient to defray the cost of the prisoner's maintenance.

The greater part of the jails throughout the country are, however, inferior to these, and are rather calculated to demoralize than to reform their inmates. Unseemly and ill-constructed buildings, often erected originally for some other purpose, and at all events poorly adapted to this, ill ventilated and frequently filthy, congregating the prisoners, whether convicted for crime, awaiting trial, or detained as witnesses, in one or two rooms, where they remain night and day, the vicious polluting the minds and depraving the tastes of the innocent, by their blasphemy and obscenity, and their boasting over the crimes they have committed; drunkenness and pilfering practised unchecked, or at least with but partial restraint; and in many cases, the jailer, a rapacious, greedy cormorant, selected in consequence of party service, and without any qualifications of humanity or moral principle for his post; all these together constitute a scene so forbidding, that it is wonderful that it should be tolerated in an intelligent and enlightened community. It is certainly desirable that in counties where the population is so sparse and the number of criminals so small as to make the burden of erecting and maintaining a good and well-regulated county jail too heavy for a single county, several adjacent counties should unite and establish a district prison, where those improvements can be adopted which shall prevent it from becoming a source of moral corruption, and over which a man thoroughly qualified for his position may be placed.

In the large cities there are other prisons deserving of notice. The large number of offenders, as well as the different authorities by which they are committed, render a classification of the prisons necessary. There are, then, in most of the large cities, *penitentiaries*, or prisons to which persons guilty of minor crimes are sentenced for periods from one month to two years, and where they are usually employed in labor during their period of imprisonment. In these, there are usually separate buildings for male and female prisoners. There are also *city* or *police prisons*, to which parties arrested by the police are committed for safe keeping till tried, and in which, if their offence is trivial, they pass their brief term of imprisonment. To these prisons are also committed prisoners convicted of capital offences, and awaiting execution, or those who having been convicted of state prison offences, are not yet sent to the convict prisons; or having appealed, await the result of their appeal. United States prisoners are also confined here. Besides these, there are prisons for persons arrested on civil process, generally known as *debtors' prisons*, though debtors are not imprisoned in most of the states, except on the charge of fraudulent conduct; there are also *houses of detention*, for witnesses; and *workhouses*, or *houses of correction*, for able-bodied vagrants. Under the general head of education, we have spoken of the *houses of reformation* for juvenile delinquents, which partake somewhat of a penal character, though having for their main object the reformation of the youthful offender.

The condition of many of these institutions is very far from what it should be, though the sums expended upon them by the city authorities have been amply sufficient to make them model institutions, if money alone could accomplish that end. Many of them are of bad construction, but the great want in most of them is of capable, upright, humane, judicious keepers—a want never to be fully remedied till the appointments are made on the ground of competency for the position, alone, without reference to political opinions.

There are, however, a few of the penitentiaries, and prominent among them the Albany (New York) Penitentiary, where the prison has been constructed under the supervision and direction of men of large experience on the subject of prison discipline, and where the officers employed have been selected solely on the ground of their adaptation to their several positions. In these institutions, the prisoners have been treated as human beings, and not being deprived of all hope or self-respect, a large proportion of them have thoroughly reformed, and on their restoration to society have proved themselves good citizens.

The improvements in the construction of prisons, as well as in their discipline and management, are due in a great degree to the unwearied labors of the late "Boston Prison Discipline Society," founded in 1826, the "Philadelphia Society for alleviating the miseries of Public Prisons," founded in 1787, and the "New York Prison

Association," founded in 1846. These societies, though the first two were engaged for years in a most acrimonious discussion of the comparative merits of the separate and silent systems, have yet diffused much valuable information on the subject of prison management. For fifteen years past the Philadelphia society has published a quarterly *Journal of Prison Discipline*, containing articles of great value and importance. The Philadelphia association has a visiting committee who visit regularly and frequently the prisoners of the Eastern Penitentiary and of the city prisons, and instruct and encourage them in their efforts to reform. Efforts are also made to protect those who are unjustly accused, and to save from prison the young who are novices in crime or dupes of the designing. This work was originated and successfully carried on in that city for many years by the late Isaac T. Hopper, a member of the Society of Friends, who subsequently removed to New York, and there was the means of organizing the New York Prison Association. The reports of this association are very valuable and interesting, and throw much light on the causes of crime and the most effectual means of repressing it, as well as on the statistics of crime both in the state of New York and in other states and countries. The association has authority from the legislature to visit, inspect, and report upon the condition of the convict and county prisons throughout the state, and by its reports has aided greatly in improving the condition and construction of the latter. It employs a general agent, who visits the city prisons, and procures the release of the innocent and friendless, and the suspension of judgment and discharge of those who, having committed trivial offences, give evidence of sincere repentance, and a determination to do better in future. The same agent also aids discharged prisoners who are desirous of leading correct lives, furnishing them, where necessary, with clothing and a small sum of money, and finding them employment.

There is also a Women's Prison Association in New York, formerly connected with the New York Prison Association, which now maintains, at 191 Tenth avenue, a refuge for discharged female prisoners, called the "Isaac T. Hopper Home." Here 121 females were received last year, on their discharge from prison, and 53 provided with good situations, 15 discharged, and the remainder retained at the Home. The effect of this institution in reforming this class of women has been excellent. Similar institutions exist in Boston, Baltimore, and other cities. In Boston, a philanthropic gentleman, Rev. Mr. Spear, has established a monthly journal, called the *Prisoner's Friend*, for the benefit of this unhappy class, and the promotion of measures for their improvement.

CHAPTER II.

HOSPITALS FOR THE INSANE.

The condition of the insane in all civilized countries has become, within the last seventy years, an object of deep solicitude to the humane. Hospitals for their treatment, or rather for their confinement, have existed in Europe for five or six hundred years; but the suffering endured, previous to the close of the last century, in these places of torment, by the hapless creatures deprived of reason, exceeds the powers of human description. The vilest galley-slave, or the most depraved heretic in the power of the pitiless officers of the Inquisition, was not subjected to such tortures as were inflicted on those who had "lost their wits," and who were so unfortunate as to be known as *lunatics*. Confinement in close, dark, damp cells, without fire, without sufficient clothing, in the most pestilential filth, loaded with chains, often cruelly beaten either at the will of their brutal keepers or as the only curative treatment, their limbs often sloughing off from the combined irritation of their chains and frost, till death, most earnestly longed for, yet sometimes so long delayed as to excite our astonishment, ended a life of inconceivable wretchedness: such was the terrible fate that awaited the insane, even in Christian lands, but eighty years ago. Nor was it those deprived of reason alone, who were consigned to a doom so terrible. The private establishments for the treatment of lunatics, and even some of the public ones, offered ready facilities for putting out of the way persons whose existence in society interfered with the covetousness, malice, or hatred of relatives or others, and whom it was not prudent to remove by poison or the assassin's knife; and many a helpless victim was consigned to a private or public "bedlam," whose fault was not insanity, but

the possession of property or affection coveted by another.

The first step for the amelioration of the condition of the insane was taken by Philip Pinel, at the Bicêtre in Paris, in 1792. He took off their chains, brought them out to the light of day, and sought to win them back to reason by kindness instead of barbarity. Humane reforms are seldom rapid in their progress, and this was no exception to the general rule. Twenty-one years later, the first movement to substitute kindness for chains, and the system of non-restraint for one of cruelty and brutality, was made in England by William Tuke, a member of the Society of Friends, at the Retreat, near York, England. Three years later the first permanent lunacy commission was appointed in England, and its reports revealed such atrocities in the treatment of these poor wretches, that reform became imperative; but in England and on the continent of Europe it is only within the last thirty years that the proper construction of insane hospitals and the truly scientific treatment of insanity may be said to have been initiated. In both particulars our country has fully kept pace with the most advanced of the European states.

At the close of the Revolution there were but two insane hospitals in the country, and of these one was a branch of a general hospital. These were the "Insane Department of the Pennsylvania Hospital," at Philadelphia, founded in 1755, and the "Virginia Lunatic Asylum," at Williamsburg, Virginia, founded in 1773. The two had less than two hundred patients. In their treatment they were probably on a par with the best institutions of the time in Europe, which is no very high encomium; chains, straps, strong, dark rooms, the strait-jacket, and very likely occasional whippings and beatings were among the remedial means employed; but this was the universal treatment of the insane. No other insane hospital was established in this country till 1817, though the number of the insane, at the commencement of the century, could hardly have fallen short of 5000 persons. These were kept in private houses, under restraint if violent, or at liberty if deemed harmless; if paupers, they were confined in jails and poor-houses, or let out to the lowest bidder, who managed, if possible, to make their services of some value, or if not, often kept them confined in pens or sheds, under circumstances of the most revolting filth and exposure. A warm room in the winter was considered entirely unnecessary for the insane, partly, doubtless, from the apprehension that they would injure themselves or others by means of the fire, and partly from an absurd notion that the feverish heat attendant upon their disease rendered them insensible to cold.

In 1817, members of the Society of Friends in Pennsylvania, moved by the success which had attended the experiment of Mr. Tuke, at his Retreat in the vicinity of York, Eng., established at Frankford, Penn., the "Asylum for Persons deprived of their Reason," a small, but, from the first, an admirably managed institution, and which has the honor of being the first in which the system of non-restraint was adopted in this country. In 1818, the McLean Asylum at Somerville, Mass., the first of the New England insane hospitals, was established. The Bloomingdale Asylum, a branch of the New York General Hospital in New York city, was founded in 1821; the South Carolina Insane Hospital at Columbia, in 1822; the Retreat for the Insane, at Hartford, Conn., in 1824; and the Kentucky Asylum at Lexington, the same year.

Up to 1840, there were fourteen insane hospitals in existence in the United States. Of these five were in the southern states, four in New England, two in New York, two in Pennsylvania, and one in Ohio. The construction of many of these was very faulty in respect to ventilation, warming, and convenience of classification of patients. Many of them were also over-crowded for their accommodations. Their management was, however, decidedly in advance of the views which had obtained in the early part of the century, and their construction, in most instances, admitted of such modifications as would make them, if not perfect, yet measurably well adapted to the comfort and welfare of their inmates. But at this time a new era commenced in the care and treatment of the insane. This was due to several causes. The managers of the Pennsylvania Hospital for the Insane, which for many years had occupied a site in the city, at the corner of Eighth and Pine streets, finding its location surrounded on all sides by a dense population, sold its property in the city, and purchased a farm of one hundred and thirteen acres in the suburbs, in 1836, and proceeded to erect upon it a hospital for the

accommodation of about two hundred patients. Having ample funds at command, and a judicious board of managers, it was resolved to introduce into the hospital all the improvements in construction which were to be found in the best insane hospitals in Europe and America. The present eminent superintendent of the hospital, Dr. Kirkbride, was elected to the post early in the progress of the work, and contributed greatly to the completeness and perfection of its arrangements. This hospital was not opened till the beginning of 1841, and its improved construction exerted a decided influence on those states which were contemplating the erection of hospitals for the insane.

A still more powerful agency in stimulating action in behalf of the insane, and leading to the erection of new and improved hospitals for them, was found in the efforts of Miss Dorothea L. Dix. Highly educated, and occupying a social position which left nothing to be desired, this heroic and noble-hearted woman, touched with the condition and sufferings of the insane, devoted herself to the work of promoting their welfare by personally investigating their condition in each state, and urging upon the legislatures the erection and maintenance of hospitals for their treatment and cure. Her memorials to the different legislatures, and subsequently to Congress, are replete with terrible facts, showing the cruel abuses to which they were subject where their care devolved upon relatives or upon the towns; and the eloquence of her appeals was almost invariably irresistible. The twenty years which have passed have increased the public hospitals for the insane to more than fifty, besides a considerable number of private asylums. Of these public hospitals, most have accommodations for 250 patients, and some of them for a much larger number. In their construction there has been jealous care exercised to introduce whatever improvements had been fairly tested, either in Europe or America; and the result is that in convenience and healthfulness, and in all the particulars of construction and management, the American insane hospitals are surpassed by those of no country in the world.* To these ends the Annual Convention of Superintendents of Insane Hospitals, first organized in 1845, and the *American Journal of Insanity*, established in 1844, have materially contributed. At the time of the commencement of the latter, not more than five or six works on insanity, including translations and reprints, had been published in this country. The number of such works is now very large. Many of the superintendents of insane hospitals have visited the European institutions, and some of them, Drs. Earle, Bell, and Ray among the number, have given to the public very full descriptions of the best institutions there. The Convention of Superintendents have agreed upon certain principles in regard to construction, number of patients, and minimum extent of grounds, desirable in the erection of hospitals; these, with other suggestions of great value and importance, have been embodied in a treatise on the construction and management of hospitals for the insane, by Dr. T. S. Kirkbride of the Pennsylvania Hospital. Drs. Beck and Ray have, in their works on medical jurisprudence, laid down with great clearness and force the principles which should govern all legal investigations concerning insanity. Dr. Macdonald gave the first public course of lectures to medical students on insanity, in 1842.

The careful investigations made by most of the superintendents into the different forms of insanity, and their comparative effect on the general health of the patient, have led to many discoveries of great importance to the community at large as well as to the medical profession. It has been fully demonstrated that early treatment at a hospital greatly increases the probability of cure; that insanity often exists long before its presence is suspected; that crimes are many times committed under an insane impulse; and that mental aberration may exist, to an extent which renders the subject irresponsible, where there is no hallucination,

* The most complete and perfect of the American hospitals for the insane, not only in its construction but in all its equipments and appliances, is the "New Pennsylvania Hospital for the Insane," near Philadelphia, opened in 1859, intended for male patients only, but in the immediate vicinity of the female department, which was opened in 1841; both being under the general supervision and management of Dr. Thomas S. Kirkbride. It is intended for 250 patients, and cost, with its complete equipment, about $350,000. It was planned by Dr. Kirkbride, and, for its size and purpose, is unsurpassed either in Europe or America. The hospitals recently erected at Northampton, Mass., and Kalamazoo, Mich., are also admirably arranged.

and no maniacal excitement, or melancholic depression. Painful evidence has been adduced that in many instances persons have perished upon the gallows whose crimes have been committed under the influence of insanity, and who should have been committed to the care of the superintendent of an insane hospital rather than to the hangman.

Within the past two or three years, insane hospitals have been established for those who have committed serious offences against the laws under the influence of insanity, and for convicts who have become insane during their imprisonment. The largest of these is at Auburn, opened in February, 1859, and which has received sixty-nine patients, fifty-five of whom are still in the hospital.

Among the improvements introduced in the treatment of the insane within the past ten or twelve years are horticulture and floriculture for those patients who can be induced to take an interest in them; libraries and reading-rooms; gymnasiums well provided with apparatus; the introduction of paintings and engravings, not only into the halls, but into the patients' rooms; games like chess, checkers, backgammon, tivoli, and dominoes, as well as those of a more active character; school exercises for a portion of the patients; parties, lectures, tableaux, readings and recitations, and other measures for diverting the mind, and recalling it from the trains of thought to which it is accustomed to revert. The success which has crowned these measures has been most gratifying. The percentage of recoveries in recent cases has been constantly on the increase, and even among those regarded heretofore as incurable, there have been many instances of recovery under the stimulus to new trains of thought thus induced.

There is still needed provision in all the states for cases of long standing, the chances of whose recovery are very slight, inasmuch as in many cases they have fallen into a condition of hopeless imbecility, or are most of the time stupid and depressed, with occasional alternations of violent mania. The safety of the community, as well as their own comfort, require that they should be in a hospital; yet most of the insane hospitals are so pressed with applications for the admission of recent cases, generally of a far more hopeful character, that they are reluctant to retain these incurables, and far more reluctant to receive them, when brought to them after years of insanity. In England, and generally in Europe, hospitals specially for incurables have been established; but this plan has its objections, as, except in cases of fatuity, it is almost impossible to pronounce positively on the curability of a given case, and the association with those whose recovery is more probable often exerts a beneficial influence upon those who have long been insane. Some measures should be adopted soon for the relief of this large class of the insane.

The fifty public insane hospitals in the country have cost on the average somewhat more than $250,000 each, or an aggregate of not less than $13,000,000. In conjunction with private asylums, they afford accommodations for a little more than ten thousand patients. According to the estimate of Miss Dix, recently published, the whole number of persons in the United States, who at some time in their lives are afflicted with insanity, is about 62,000. This would indicate an alarming deficiency of hospital accommodations for this unfortunate class. That there is a great deficiency is undoubtedly true, but it is not quite so large as these figures would indicate. The population of the hospitals is a constantly changing one, and the discharges in any one year will amount to very nearly one half of the number in the hospital. It is safe therefore to conclude that the present hospital accommodations are sufficient for nearly or quite one half the insane. They are, however, unequally distributed. Massachusetts has five public and several private hospitals, furnishing accommodations for nearly 1500 insane; Connecticut, with nearly one half the population, has but one public institution, having accommodations for 250, and one small private asylum. New York has but five public, and several private hospitals, the public hospitals affording accommodations for not more than 1600 patients; while Pennsylvania, with a considerably smaller population, has seven public hospitals, with accommodations for about 1800 patients.

The newer states are not, as yet, fully provided with hospital accommodations for the insane, though most of them have commenced their erection.

The character of our population, active, restless, eager, and impulsive, is such as to make insanity more prevalent than in most other countries; and it is of a different

STATISTICS OF INSANE HOSPITALS IN THE UNITED STATES, 1860.

Name of Hospital.	Location.	Date of opening.	Patients at beginning of year.	Admitted durin. year.	Discharged.	Remaining at end of the year.	Discharged cured.	Discharged not cured.	Died.	Percent. of recoveries.	Percentage of deaths.	Percentage of recoveries on admissions.	Superintendents.	Receipts.	Expenditures.
State Insane Asylum	Augusta, Me	1840	208	149	120	237	58	45	17	26.12	7.65	38.92	Dr. Harlow	$32,421	$32,726
" " "	Concord, N. H	1843	165	85	66	184	38	28	17	21.71	9.71	44.70	Dr. Bancroft	31,855	31,227
Insane Asylum	Brattleboro', Vt.	1836	434	143	138	436	58	43	37	18 39	8.54	40.55	Dr. Rockwell	59,270	57,810
McLean Asylum	Somerville, Mass.	1818	186	131	142	175	61	53	28	39.60	18 70	46.45	Dr. Tyler	64,115	61,627
State Lunatic Hospital	Worcester, "	1833	301	200	184	317	89	65	30	28.80	9.70	44.50	Dr. Bemis	60,451	60,220
" " "	Taunton, "	1854	301	231	149	341	..	..	42	..	13.08	..	Dr. Choate	63,666	61,454
" " "	Northampton, "	1858	220	93	61	233	33	28	19	14.60	8.40	35.48	Dr. Prince	47,577	46,145
Boston Lunatic Hospital	Boston "	1839	123	96	80	139	39	20	21	29.77	16.03	40.62	Dr. Walker	29,782	29,782
Butler Hospital for the Insane	Providence, R. I.	1848	135	42	42	135	14	18	10	10.37	7.40	33.33	Dr. Ray	30,696	31,090
Insane Retreat	Hartford, Conn.	1824	215	168	156	227	70	66	20	31.67	9.05	41.66	Dr. Butler	45,816	40,653
State Lunatic Asylum	Utica, N. Y.	1843	502	312	295	519	114	146	35	22.30	6.85	36.53	Dr. Gray	118,545	109,465
City "	New York, "	1838	655	389	247	711	148	99	86	21 67	12.59	38.05	Dr. Ranney	49,615	50,318
Bloomingdale Lunatic Asylum	" "	1821	145	188	131	152	55	58	18	36.91	12.08	39.85	Dr. Brown	49,149	40,205
King's County "	Flatbush "	1845	290	180	162	308	87	49	26	29.10	8.69	48.33	Dr. Chapin	..	..
Criminal Insane Asylum	Auburn	1859	51	18	14	55	12	1	1	22.64	1.88	..	Dr. Hall	..	..
Pennsylvania Hospital for the Insane	Philadelphia, Penn.	1841	254	211	191	274	98	67	26	37.12	9.84	46.44	Dr. Kirkbride	84,144	86,497
City Lunatic Asylum	" "	..	406	376	366	416	115	140	111	27.97	27.00	30.59	Dr. Smith	..	..
Asylum for persons deprived of their reason (Friends' Asylum)	Frankford "	1817	62	25	29	58	10	15	4	16.66	6.66	40.00	Dr. Worthington	..	..
State Lunatic Hospital	Harrisburg, "	1854	267	143	136	274	31	82	25	11.48	8.59	21.67	Dr. Curwen	59,079	58,997
Western Pennsylvania Insane Hospital	Pittsburg, "	1856	74	83	67	90	34	19	12	41.46	14.60	40.96	Dr. Reid	24,000	23,734
State Lunatic Hospital	Trenton, N. J.	1848	293	186	173	306	76	71	26	28.00	8.66	40.86	Dr. Buttolph	51,525	51,523
State Lunatic Asylum	Baltimore, Md.	1834	108	97	101	110	69	19	13	63.30	11.92	71.13	Dr. Fonerden	..	..
Mount Hope Institution for the Insane	Mount Hope, "	1842	144	135	102	177	39	47	16	24.37	10.00	28.88	Dr. Stokes	..	..
Eastern Virginia Insane Asylum	Williamsburg, Va	1773	257	167	121	300	33	31	59	11.82	21.14	19.76	Dr. Galt	66,518	55,458
Western " "	Staunton, "	1828	389	102	119	372	62	17	40	16.31	10.52	60.78	Dr. Stribling	..	..
United States Insane Hospital	Washington, D. C.	1857	110	43	36	117	18	5	13	15.80	11.40	41.86	Dr. Nichols	24,500	24,500
Insane Asylum	Raleigh, N. C	1856	138	57	49	146	24	16	9	16.90	6.34	42.10	Dr. Fisher	30,000	30,000
" " "	Columbia, S. C.	1822	184	63	53	194	25	9	19	13.23	10.05	39.68	Dr. Parker	47,142	45,087
" " *	Midway, Georgia	1840	..	..	..	..	..	..	..	..	..	..	..	85,630	85,000
" Hospital*	Tuscaloosa, Ala.	1855	..	..	..	..	..	..	..	..	..	..	..	..	..
" Asylum	Jackson, Miss	1854	105	47	48	106	14	17	19	18.33	18.09	29.78	Dr. Kells	80,065	85,315
" "	Jackson, La	1855	137	97	77	157	34	6	37	21.29	25.17	35.05	Dr. Barkdull	31,167	31,129
Tennessee Asylum	Nashville, Tenn.	1852	105	122	69	158	28	22	19	21.21	14.39	22.19	Dr. Cheatham	52,426	48,000
Eastern Kentucky Asylum	Lexington, Ky.	1824	226	45	43	228	19	15	9	8.37	3.96	42.22	Dr. Chipley	..	..
Western "	Hopkinsville, "	1846	87	95	74	108	38	18	18	38.77	18.36	40.00	Dr. Monigomery	..	..
Missouri Asylum	Fulton, Mo.	1858	135	122	86	171	45	19	22	29.41	14.37	36.88	Dr. Smith	..	38,920
Northern Ohio Lunatic Asylum	Newburg, O.	1855	141	140	133	148	75	54	4	52.08	2.80	53.57	Dr. Kendrick	..	..
Central " " "	Columbus, "	1838	259	175	179	255	101	59	19	39.34	7.39	57.71	Dr. Hills	..	93,423
Southern " " "	Dayton, "	1855	161	116	117	160	73	27	17	45.60	10.60	62.93	Dr. McIlhenny	..	..
Hamilton County Insane Asylum	Cincinnati "	1852	179	158	107	230	46	49	12	22.55	5.88	29.11	Dr. Mount	..	..
†Michigan Insane Hospital	Kalamazoo, Mich	1859	111	..	..	..	..	..	..	..	..	..	Dr. Van Dusen	..	..
Indiana " "	Indianapolis, Ia.	1848	277	203	177	303	95	70	12	32.76	4.14	47.29	Dr. Athon	..	36,196
Illinois " "	Jacksonville, Ill.	1851	214	312	297	229	164	91	42	73.87	19.82	52.56	Dr. McFarland	36,000	36,000
†Wisconsin " "	Madison, Wis.	1860	..	..	..	..	..	..	..	..	..	..	..	..	..
†Iowa " "	Mt. Pleasant, Iowa	1861	..	..	..	..	..	..	..	..	..	..	..	..	..
California " "	Stockton, al	1853	273	276	124	370	40	35	49	12.38	15.17	14.49	Dr. Aylett	..	..
†Texas " "	Austin, Texas	1858	..	..	..	..	..	..	..	..	..	..	..	10,000	..

There are also County Hospitals for the insane at Albany, Canandaigua, Troy, and Buffalo, N. Y., an Insane Hospital for Emigrants, just opened, on Ward's Island, N. Y., and private asylums at Dorchester and Pepperell, Mass., Litchfield, Conn., Flushing, etc.

* No report.

† Just opened, or nearly ready for patients.

type, assuming oftener the violent form; while in Europe, the pauper insane, who form the largest portion of those afflicted, have usually become so under the influence of insufficient food and depressing circumstances, and are melancholy and dejected, rather than violent.

The preceding table, prepared with great care, exhibits the condition and success of nearly all the public insane hospitals of the United States, up to January, 1860, though a few of the returns of the remoter institutions are of the previous year.

CHAPTER III.

THE RELIEF OF THE POOR.

In every large community there is, of necessity, a dependent class, to be in some way provided for; their poverty and helplessness may proceed from the loss of their protectors, the husband or parents, at a time when they were unable to provide for themselves; from sickness; from mental or physical incapacity for self-support; from lack of employment; or from intemperance and vicious indulgence.

Whichever of these causes may have induced this state of dependence, it is a recognized duty in all civilized communities to diminish, and so far as possible prevent, extreme suffering on the part of those thus helpless.

The methods of accomplishing this result are of necessity various. All who need, at times, pecuniary aid, are not paupers; and to treat them as such would not only wound and distress them needlessly, but would in the end produce a demoralization and indisposition to exertion which would throw an intolerable burden on the tax-paying class, who would be compelled to support them.

It was the recognition of this truth which led very early to the organization of asylums, dispensaries, and relief societies for the orphan and the widow (especially those of certain classes), the aged and infirm, and the sick. It led also to the administration of private charities, which, although sometimes injudicious, was prompted by the most humane motives. It also led to the distinction between the out-door poor and the pauper, which is commonly established in our large towns.

The methods of providing for the poor, as well as the authorities who take charge of it, vary in different sections of the country. In New England, where the *town* was an older political organization than the county, province, or state, the legal care of the poor has always devolved upon the first town officer, or selectman, as he is usually called. To him all applications for assistance are made, and after the necessary examination into their condition and necessities, relief is furnished, to a limited extent, from the town treasury. Those needing only temporary assistance receive small sums, and are encouraged to struggle on at their homes; those wholly dependent are provided for, in the smaller towns, by contract with some citizen, who for a stipulated sum agrees to provide them with food, clothing, and shelter, employing such of them as are able to perform some labor, in such work as their health or want of skill will permit. In the larger towns, this class are received into almshouses, to which often a farm is attached, much of the lighter labor of which is performed by the paupers. Paupers of foreign birth, who have never gained a residence in any town, as well as vagrants who have no fixed abiding place, are sent to a state almshouse, or placed in charge of a state contractor for the poor.

In the middle and western states, the assistance to the poor and the support of paupers are a *county* charge, and are under the control of supervisors elected by the voters of the county. Those entirely dependent are usually quartered in a county almshouse, and, where practicable, employed in light labor. In the Southern states, with a milder climate and a sparser population, there is less occasion for definite preparation for the wants of a pauper class, especially as a very considerable portion of those who would elsewhere be dependent upon the public are, from the peculiar constitution of their institutions, cared for, when infirm, sick, or disabled, by their masters. Hence, except in the cities and large towns of the South, there has been no well-defined provision for paupers.

At the close of the Revolution, there was a vast amount of poverty and suffering, the result of the prostration of commerce, the ravages of war, the loss of the productive industry of so large a number of able-bodied men for several successive years, and the complete and ruinous depreciation of the continental currency. From this condition, however, under the stimulus of an active and prosper-

ous trade and commerce, the country soon rallied, and though the war of 1812 brought much privation and loss of property, yet the constant westward emigration, and the enterprise of the people, kept the pauper population within narrow limits. The poor were mostly natives of the country, and the ties of kindred were strong enough to prevent the burden of their support from pressing heavily on the public treasury.

In the larger towns, and especially in the seaports, where there was the largest influx of persons of foreign birth, and of families reduced to poverty through the vicissitudes of a seafaring life, there were benevolent societies, some of them dating back almost to the revolutionary period, of the different nationalities, which bestowed aid on their own countrymen, and marine societies (that of New York founded as early as 1770) to provide for the widows and orphans of seamen. There were also one or two dispensaries in the larger towns, for providing medical attendance and promoting vaccination among the poor. Between 1800 and 1830, relief societies, some of them connected with particular trades or professions, such as the tailors', house-builders', firemen's, etc., some composed of persons of particular nationalities, as the Germans, Irish, etc., and others of a more general character, like the Masonic, Odd Fellows', and Temperance Lodges, were organized, having for their object the care of the sick, and provision for the widows and orphans of their members. The New York Hospital opened in 1792, the City Hospital at Bellevue, the New York Eye and Ear Infirmary founded in 1820, the City Dispensary founded in 1791, the Northern Dispensary founded in 1827, and the Lying-in Asylum founded in 1824, afforded the necessary medical treatment to those who were without means to pay for the attendance of a physician. Soon after 1830, however, the tide of European emigration began to set westward, and with each successive year, larger and still larger numbers of emigrants, at first mainly from Ireland, but subsequently in quite as large numbers from the German states, began to pour in upon us. Many of these possessed a small amount of money, and others, stout and able-bodied, found ready employment at remunerative wages, and provided well for themselves and families.

No inconsiderable portion, however, had either been paupers at home, or coming here with insufficient means, their manners, customs, and language diverse from ours, and the climate, under their privations, proving far more severe than that of their native country, sunk down into a hopeless and despondent pauperism almost immediately on their arrival. With the intent of obviating this influx of foreign pauperism, stringent laws were passed by the states having extensive commercial relations with Europe, prohibiting the reception, by captains of emigrant ships, of pauper emigrants, and a tax of two dollars per head required of all emigrants arriving at the principal ports, or a bond by the ship-owners to the state that they should not become chargeable to the state within three years. These laws were so constantly evaded, and the pressure of foreign pauperism in consequence became so severe in New York, the great port of entry for emigrant ships, that a modification became necessary, and a board of Commissioners of Emigration was appointed to receive the emigrant tax, which was raised to three dollars, and they were required to establish hospitals, almshouses, etc., and to assume the entire responsibility for the pauperism of emigrants for five years after their arrival.

Measures nearly as stringent were adopted by Massachusetts and Pennsylvania.

Notwithstanding these efforts to restrain within due metes and bounds the influx of foreign pauperism, and prevent its becoming chargeable upon our own citizens, its increase in New York, Massachusetts, and Pennsylvania, has been such as to create no small degree of alarm on the part of the taxpayers. The state of New York alone had, in 1859, above 260,000 paupers, being 7.4 per cent. of her population, or nearly one pauper for every 13 persons. This proportion is about eight times that of Ireland, and more than double that of the United Kingdom of Great Britain and Ireland; and formidable as it is, it does not include any of those under the care of the Commissioners of Emigration. The increase of pauperism has been nearly fifteen times that of the population within the last thirty years. Of this increase more than 75 per cent. are either of foreign birth or the children of foreigners. In New York city the proportion of foreigners exceeds eighty per cent.

These statistics, however, by no means tell the whole story in regard to the dependent poor of the great cities. Large numbers, who are unwilling to be enrolled on

COMPARATIVE STATISTICS OF POOR RELIEF IN ENGLAND, FRANCE, MASSACHUSETTS, AND NEW YORK.

	England. 1859.	France. Average from 1848 to 1852.	France. 1858.	Massachusetts. 1858.	Massachusetts. 1859	New York. 1858.	New York. 1859.
Number of almshous , poorhouses, or work-houses	749	..	..	212	222	60	60
Land attached to these houses	..	..	..	21,276	21,601	7,208	7,691
Number of persons relieved in almshouses, etc.	107,050	618,207	542,323	11,845	10,369	38,582	36,550
Out-door poor	692,384	982,516	1,022,996	23,071	21,954	333,405	279,717
Cost of support of poor in almshouses	$12,644,906	..	$13,431,379	$435,661	$380,149	$1,121,222	$927,581
Average *weekly* expense of each pauper in almshouses	$2.27	..	$1.13	$1.57	$1.47	cts. 90.5	cts. 71.8
Average *yearly* expense of each pauper in almshouses	$118.12	..	$58.76	$81.64	$76.44	$46.06	$37.34
Expenditure for out-door poor	$14,259,149	..	$3,420,585	$284,963	$356,096	$748,196	$677,680
Average expenditure per head per annum for out-door poor	$20.59	$2.23	$2.33	$12.35	$16.22	$2.24	$2.42
Total expenditure for legal relief of poor	$26,904,055	..	$27,886,554	$720,624	$736,245	$2,123,974	$1,877,908
Population	19,578,000	..	36,012,669	1,231,494	1,231,494	*3,735,607	*3,735,607
Ratio of expenditure for paupers to population	$1.37	..	cts. 77.4	cts. 58.5	cts. 59.8	cts. 56.6	cts. 50.2
Whole number of paupers	902,052	1,726,236	1,694,495	58,907	49,137	399,839	344,763
Percentage of paupers to population	4.60	4.79	4.70	4.78	3.99	10.70	9.20
Number of insane paupers	19,487	..	..	1,176	1,142	3,457	4,299
Valuation of property of country or state	..	..	..	..	$897,795,326	..	$1,416,298,837
Percentage of poor-rate to valuation	..	..	..	..	.0008	..	.0013
Percentage of the poor-rate of the whole tax of the country or state	..	..	34.4	..	31.6	..	11.0

*Except Albany County.

the city or county records as paupers, are still dependent for a considerable share of their support, especially during the winter months, on private charity, bestowed either through the churches with which they are connected or some of the societies or associations devoted to the relief of the poor. These organizations have greatly increased within the past twenty years, in all our large cities, and though varied in their specific purposes, they all have the general object of ameliorating the condition of the poor. For the sick poor, hospitals, dispensaries, and infirmaries have been greatly multiplied; for the aged and infirm and for very young children, homes and nurseries have been established; for widows and orphans, widows' societies, assistance societies, and orphan asylums; for the disabled, relief societies; for youthful offenders or the morally endangered, asylums, houses of reformation, houses of industry, children's aid societies, and "missions;" for the intemperate poor, inebriates' homes and Samaritan homes; and for the poor in general, associations for improving the condition of the poor, provident societies, soup houses, etc., etc.

In addition to these, very large sums in the aggregate are bestowed by the benevolent in private charity to the poor and suffering, and sums almost as large in contributions to the importunate mendicant, by those who give from impulse and a naturally generous disposition.

The great increase of mendicancy, and the annoying importunity of the beggars who preferred a living obtained in that way to one acquired by honest toil, led to the formation of a class of organizations now existing in most of the large cities in the country, but originating in the city of New York. In different cities different names for these organizations have been adopted, but their general purpose is the same. "The New York Association for Improving the Condition of the Poor," was not only the first but has been the most efficient in its action. Its purposes, and those of its kindred associations, of which there are now thirteen in as many of our large cities, are, "to discountenance indiscriminate almsgiving and put an end to street begging and vagrancy; to visit the poor at their dwellings, and extend to them appropriate relief; and through the friendly intercourse of visitors to inculcate among them habits of frugality, temperance, industry, and self-dependence." Each city, where one of these associations exists, is divided into districts, which are again divided into sections (New York has almost four hundred of these sections), to each of which a visitor is appointed, who takes upon himself, without compensation, the entire oversight of the poor of his section, visiting them, ascertaining their situation, their resources, if any, their just claims upon any other organization for relief, and where necessary, rendering them such assistance as will enable them to subsist until they can obtain work or aid from quarters where they have a claim for it, or if they need assistance, bestowing it in such a way as not to destroy their desire for self-dependence or injure their self-respect.

To check street begging, every member (and any person contributing to the funds of the association is a member) is furnished with printed cards and a directory showing the residence of the visitors and the section which they have in charge, and when a beggar applies for charity, the member inquires his residence, and instead of giving him money, gives him a card with the address of the visitor upon it, and directs him to call upon that visitor, who will investigate his case, and if proper, render him aid.

These associations have also been active in promoting sanitary reforms, encouraging the erection of well-arranged tenement houses, in preventing truancy, in aiding in the formation of temperance societies, in promoting the establishment of dispensaries and houses of reformation, and in diffusing, by means of tracts and handbills, information among the poor on the subject of cleanliness, ventilation, and household economy.

Ignorance, intemperance, licentious indulgence, the congregation of such large numbers in filthy, ill-arranged, and ill ventilated tenement houses, and disregard of sanitary laws generally, are the causes of more than four fifths of the pauperism of our great cities, and it is only by removing these causes that any considerable diminution in the number of paupers can be expected. The small dependent class whose poverty is not traceable to either of these, can readily be provided for; but the terrible burden of taxation to maintain those who are paupers from their own fault or that of their parents, renders it certain that there must be, ere long, carefully considered, but stringent legislation to prevent the evils which inflict such a burden on the industry of our people.

CHAPTER IV.

HOSPITALS.

HOSPITALS for the sick, either general or special, have been in existence in Europe from the early Christian ages, and their endowment has been a favorite form of Christian charity. In this country, the first general hospital was the Pennsylvania, at Philadelphia, opened in 1752. The charter, granted in 1751, contemplated "the reception and relief of lunaticks and other distempered and sick poor in this province," and it has always had a department for the insane, who occupied a portion of the hospital building until 1841, when they were removed to the Pennsylvania Hospital for the Insane, then completed, which we have described under the head of Hospitals for the Insane. This building, now the female department of the insane hospital, was erected mainly from funds resulting from the sale of the hospital land, and the general hospital has, aside from this, a permanent fund of nearly $400,000 invested, the income of which sustains nearly 150 free beds. The average number of inmates is below 200. The medical staff, selected by the managers, serve gratuitously, and are the most eminent members of the profession in the city. There is a library of over 10,000 volumes attached to the hospital. Benjamin West's picture of "Christ Healing the Sick" was painted for this hospital, and its exhibition added $24,000 to its funds.

The New York Hospital, the first in New York, was incorporated in 1771 by the colonial legislature, but was not opened for the reception of patients till 1791. At first it had wards for the insane, like the Pennsylvania Hospital, but in 1818 the governors of the hospital established a separate asylum for the insane at Bloomingdale, with an efficient superintendent and corps of officers, but under their general supervision, and supported in part from their funds. The general hospital has grown up to be a very large and admirably managed institution. It is a close corporation, under the control of 26 governors. All cases of serious accident or emergency are admitted immediately, without regard to payment or recovery; otherwise, persons whose cases appear not to admit of cure or relief, are not received. It has four physicians and six surgeons in regular attendance, besides a house physician and several assistants. The entire medical staff is twenty-four. There are about 500 beds. The cost of each patient is $4.32 per week. The rate of deaths to the whole number of patients is only about 5½ per cent.; being less than that of any hospital in Europe. Connected with the hospital is a library of between 6000 and 7000 volumes.

The Massachusetts General Hospital at Boston, founded in 1817, is an institution of high character and reputation. It has funds to the amount of about $300,000; a medical staff of 20 physicians and assistants, and about 200 beds. It is managed by a board of trustees, and a president, vice president, secretary, and treasurer. It has an out-door department, furnishing medical and surgical aid to over 3000 out-patients. The McLean Insane Asylum, at Somerville, is a branch of the hospital. The annual expenditure is nearly $100,000.

There are now in the city of New York fourteen hospitals, and five other institutions having hospital accommodations. Of these, seven are general, and receive patients of all classes except those with contagious diseases; one is for small pox, one for syphilitic diseases, one for quarantine patients, two exclusively for women, one for children, and one for diseases of the eye. Of the five institutions having hospital accommodations, one is for lying-in women, two for young children, one for aged females, and one for colored persons. There are also hospitals connected with the Orphan Asylums, House of Refuge, and Juvenile Asylum, for the sick inmates of those institutions. The entire capacity of these hospital accommodations exceeds 7000 beds.

Philadelphia has eleven hospitals, four of them general, one naval, one for infectious disease, one a lying-in charity, one for diseases of the eye and limbs, and three for aged and indigent females. The entire number of beds does not exceed 1600.

Boston has eight hospitals, of which five are general, and one for diseases of the eye and ear, one for aged and indigent females, and one a lying-in hospital.

Brooklyn, N. Y., has five, two of them general, one naval, and two for aged women.

Baltimore has three, two of them general, and one for aged women.

Charleston has two hospitals, and Norfolk, Va., two, a naval and city institution.

Cincinnati has three, one a commercial hospital, one a hotel for invalids, and one a widows' and female asylum and hospital.

STATISTICS OF HOSPITALS IN NEW YORK, BOSTON, AND PHILADELPHIA, WITH COMPARATIVE STATISTICS OF PARISIAN HOSPITALS.

Name of hospital.	Date of organization.	Whole number of patients.	Males.	Females.	Cured.	Relieved.	Not relieved.	Died.	Percentage of deaths.	Total receipts.	Total expenditures.	Total expenditure for free patients.	Expenditure for food.	Expenditure for fuel.	Expenditure for medicines, &c.	Expenditure for clothing and bedding.	Expenditure for salaries.	Cost of food per head per week.	Whole cost per head per week.	Charge per week to pay patients.	Whole number of pay patients.	Whole number of free patients.
New York Hospital	1791	3,115	..	..	2,045	384	89	316	10.1	$46,596	$57,706	$29,609	$24,467	$6,193	$5,702	$1,486	$14,695	$1.71	$4.04	$4.00	1,927	1,188
St. Vincent's Hospital	1849	600	277	323	186	236	53	125	20.8	11,074	11,926	3,069	5,752	784	729	620	2,125	1.82	3.70	3.00	396	204
St. Luke's Hospital	1859	468	232	236	320	..	89	59	12.6	16,308	15,715	14,177	6,751	1,492	701	736	3,856	*1.91	4.25	4.00	56	412
The Jews' Hospital	1852	387	180	107	185	48	7	23	7.67	15,817	7,193	6,918	2,443	328	423	204	1,470	1.38	4.07	4.00	..	..
The Woman's Hospital	1855	130	..	130	52	41	4	2	1.54	8,512	8,958	..	..	..	..	..	..	..	..	4.00	..	..
Child's Nursery and Hospital	1854	607	..	..	463	..	22	106	17.46	10,543	8,854	4,331	4,572	1,238	..	489	1,469	0.51	0.98.4	1.20	..	..
Hospital for Women	1853	106	..	106	..	..	..	..	..	5,088	3,718	1,500	1,869	196	..	..	..	..	..	4.00	..	..
Colored Home and Hospital	1840	582	116	466	..	..	..	97	16.6	15,483	12,184	12,184	3,730	758	284	852	1,300	†0.23	†0.75	..	none	all.
Lying-in Hospital	1823	87	..	87	79	2	6	..	..	2,171	2,081	2,081	863	368	60	..	573	..	3.93	..	..	..
Bellevue Hospital	..	11,411	6,819	4,592	..	..	..	1,013	8.88	119,414	119,414	119,414	39,480	12,422	10,168	10,547	14,622	0.80	1.80	..	none	all.
Island Hospital	..	6,125	1,820	4,305	..	..	..	158	2.58	31,426	31,426	31,426	17,407	2,911	2,884	3,148	4,445	0.79	1.43	..	none	all
Small Pox Hospital	..	339	204	135	..	..	..	36	10.62	3,454	3,454	3,454	1,113	608	364	254	930	0.83	2.67	..	none	all.
Emigrants' Hospital	..	4,729	2,848	1,881	3,014	..	..	226	4.79	58,913	58,913	58,913	26,065	13,372	5,825	2,782	17,035	0.69	1.57	..	none	all.
Nursery Hospital, Randall's Island		1,329	..	..	..	924	298	107	8.	20,844	20,844	20,844	..	..	..	..	4,292	..	1.48	..	none	all.
Massachusetts General Hospital	1835	1,394	848	546	698	305	134	121	8.69	45,749	42,578	36,148	16,337	3,397	3,657	1,583	12,451	2.45	6.42	4.50	257	1,137
Pennsylvania Hospital	1752	1,958	1,570	388	1,351	248	167	131	6.79	35,845	35,139	24,623	15,158	2,630	3,677	1,927	7,894	1.69	3.93	4.00	623	1,173
Total for 16 American Hospitals.		34,067						2,520	7.4	$447,237	$440,103								‡2.93			
Hospitals of Paris—1858	..	88,237	..	..	78,913	..	..	9,283	11.76	$998,206	$998,206	$998,206	..	..	..	..	..	..	$3.02	..	none	all.

* This is exclusive of large donations of cooked food made to the hospital.

† Exclusive of donated food, and vegetables raised on the extensive grounds of the hospital.

Name of Institution or Department rendering assistance.	Number in charge of department, etc., January 1, 1860.	Received during year 1860.	Discharged during year 1860.	Remaining in charge of department, January 1, 1861.	Total in charge of the department throughout the year.	Males, January 1, 1861.	Females.	Children.	Natives.	Foreigners.	Total amount of assistance.	Cost per head per day.	Cost per head per week.	Assistance rendered in clothing.	Assistance rendered in food.	Assistance rendered in fuel, etc.	Assistance rendered in medicine.	Assistance rendered in money.	Number of deaths.	Number of insane, demented, or idiotic.	Number of births.
Almshouse, Blackwell's Island	1,770	4,129	3,860	2,039	5,899	955	868	216	429	1,610	$79,842	c.35.8	$2.50	$15,864	$42,662	$13,973	....	....	455	200	..
Bellevue Hospital	860	10,551	10,485	926	11,411	519	355	52	167	759	119,414	25.7	1.80	10,547	39,480	13,422	$10,168	....	1,013	15	474
City Prison (insane paupers)	..	..	..	..	..	..	..	..	....	....	....	....	....	....	....	....	....	....	34	859	3
City Lunatic Asylum, B. Island	711	401	358	754	1,112	301	453	40	199	555	92,361	22.5	1.57	15,899	18,675	14,549	....	....	118	754	..
Randall's Island Nursery	1,142	1,397	1,360	1,153	2,539	53	101	999	*842	264	43,774	21.2	1.48	15,822	33,823	21,505	....	....	82	..	..
" " " Hospital	256	1,073	1,031	298	1,329	..	..	298	....	....	20,858	....	....	....	....	....	....	....	107	..	..
Workhouse, Blackwell's Island	1,387	11,641	11,601	1,427	13,028	675	752	..	....	....	88,961	22.2	1.55	25,607	35,279	18,006	....	....	21	..	..
Colored Home	293	568	556	305	861	..	..	..	....	....	17,814	15.6	1.09	1,096	7,781	1,339	984	....	98	..	71
Colored Orphan Asylum	211	70	66	215	281	..	..	..	....	....	19,735	24.1	1.68	1,796	5,903	1,167	375	....	7	..	..
Island Hospital, Blackwell's Isl.	431	1,175	1,254	352	1,606	96	256	93	93	259	31,426	20.02	1.40	3,148	17,407	2,711	2,884	....	54	..	..
Small Pox Hospital, Blackw's Is.	16	323	296	43	339	26	17	..	6	37	3,454	38.09	2.66	254	1,118	608	364	...	36	..	..
Out-door poor for the year	7,077	79,780	..	..	79,780	adl'lts. 83,679		46,101	*3,896 †35,818	*29,783 †10,283	107,348	..	..	...	....	32,736	....	$28,535	..	..	..
Totals for municipal relief	86,857	111,108	30,367	7,512	118,185	..	..	47,706	41,450	43,530	$624,482	25.0	$1.75	$89,933	$202,073	$120,016	$14,775	$28,535	2,015	1,828	548
COMMISSIONERS OF EMIGRATION.																					
Total assistance afforded	..	..	..	..	20,715	..	..	..	....	....	$206,064	..	..	....	....	....	....	....	....	....	....
Refuge and Hospital, Ward's Isl.	764	3,965	3,661	1,068	4,729	2848	1881	557	422	4,307	58,913	22.4	$1.57	$26,065	$2,782	$13,373	$18,192	$5,825	226	204	264

If to the municipal relief, $624,482, we add that afforded by the Commissioners of Emigration, $206,064, and that furnished by the voluntary charitable associations of the city, which by careful investigation has been demonstrated to amount to $586,119 for the year 1860, we have a total aggregate of $1,416,665 for the public relief of the poor in the city of New York. The amount bestowed in private charity cannot, of course, be estimated.

* Adults. † Children. A large portion of these are children of foreigners, though themselves born in this country.

Chicago has a marine hospital.

St. Louis has four, one for quarantine, one marine, and two general; one of them under the care of the Sisters of Charity.

New Orleans and Mobile are more amply supplied with hospitals in proportion to their population than most of the cities of the Union, the former having four, one of them a United States naval hospital. The Charity Hospital at New Orleans is the largest in this country, receiving from 13,000 to 20,000 patients a year, and having about 1000 beds. Mobile has three, one marine and two general. All are large, and admirably managed.

Most of the cities of twenty thousand inhabitants and over have one, and some of them more than one hospital, though ordinarily their wards are by no means full.

CHAPTER V.

DISPENSARIES.

Another of the methods of relief and ministration to the wants of the poor has been the establishment of Dispensaries. The idea of such institutions originated, we suppose, in Rome, but was not adopted in other cities till the latter part of the last century. In London, a dispensary was established in 1696. There was none in Paris till 1803. At first, it was simply an apothecary's shop, where medicines were dispensed gratuitously to the poor. After a time, a physician attended at a certain hour to prescribe for patients who might require treatment; then, as the number of patients increased, they were classified, and other physicians volunteered to take charge of the different classes, and a house physician and apothecary were appointed to take the general oversight, keep the records, prepare medicines, arrange the patients for the classes, etc.; then, as it was found that many of the sick poor were unable to come to the dispensary to receive treatment, and some of those who came once or twice were unable to continue to attend, and so suffered for the want of medical care, the plan was adopted of dividing the region appertaining to the dispensary into districts, to each of which a district physician was appointed who visited the sick at their dwellings. Vaccination, from its first introduction, was largely practised at the dispensaries; and nearly all of them now give attention to it, keeping a supply of the vaccine virus constantly on hand, and vaccinating all who apply, and at some seasons of the year calling the attention of the people to the necessity of it. To some of the dispensaries a lying-in department is added.

The first dispensary in this country was the Philadelphia, founded in 1786.

The New York Dispensary, the first in that city, was founded in 1791, and the Boston Dispensary in 1796.

There are now in New York five public dispensaries, covering the whole city below Sixtieth street west of Fifth avenue, and below Fortieth street east of that avenue. The territory of the city below these streets is parcelled out between these dispensaries, in such a way as to give to each a district not excessive either in size or population. Each dispensary employs two or more district physicians, to visit the sick poor at their homes when they are unable to come to the dispensary. The patients who come to the dispensary between the hours of 10 A. M. and 4 P. M., are divided into eight or nine classes, each of which has its room, where the physician in attendance prescribes for the patients belonging to his class. The medicines prescribed are furnished by the institution, and though plainly put up, great care is taken to have them uniformly of the best quality.

Besides these, there are three homœopathic dispensaries in the city, and four other institutions of a dispensary character, intended for special diseases, two of them for diseases of the eye, and two for women and children.

Philadelphia has three dispensaries, two of them with a lying-in department. It has also several institutions which dispense medicine to the poor, and prescribe for them in particular forms of disease, in connection with the hospital or asylum accommodations.

Boston has one central dispensary, which is largely endowed, although its funds are not yet available. This dispensary has two consulting and eight attending physicians, two consulting and four attending surgeons, a medical superintendent and apothecary, and eight district physicians, who divide between them the city territory and visit all the sick poor who apply, and who are unable to attend at the dispensary. The Massachusetts General Hospital also affords medical and surgical relief to out-patients, to a very considerable extent.

LEADING STATISTICS OF THE FIVE NEW YORK DISPENSARIES AND THE BOSTON DISPENSARY FOR THE YEAR ENDING JANUARY 1, 1860.

Name of Dispensary, and date of incorporation.	Sexes and ages of patients.				Grand total of each dispensary.	Patients where treated.		Vaccination.			Results.			Prescriptions, their number, average, and cost.			Financial.			Nativity of patients.	
	Males.	Females.	Adults.	Children under fifteen years of age.		At the Dispensary.	At their dwellings.	Number of primary vaccinations.	Number of revaccinations.	Whole number vaccinated.	Number sent to hospital.	Number of deaths.	Number discharged cured or relieved.	Whole number of prescriptions.	Average No. to each patient.	Average cost of each prescription.	Total expenditure per year.	Average cost of service to each patient.	Average cost of medicine to each patient.	Of American birth.	Of foreign birth.
New York, *A. D. 1791*..	18,317	25,222	23,525	18,014	43,539	37,140	6,399	1,567	50	1,667	5,428	272	37,839	102,591	2.45 cts.	02.78	$5,706 20	13.1 cts.	6.6 cts.	19,358	24,181
Northern, " 1827..	7,653	11,883	11,129	8,407	19,536	15,033	4,503	1,289	109	1,398	143	95	19,298	30,840	1.7 "	06.22	3,833 62	19.62 "	2.81 "	9,088	10,448
Eastern, " 1832..	12,920	17,132	14,948	15,104	30,052	23,758	6,294	5,116	2,051	7,167	918	157	28,977	55,658	2.28 "	03.9	4,421 16	14.7 "	7.4 "	15,250	14,802
Demilt, " 1851..	11,229	15,387	15,479	11,137	26,616	18,550	8,066	1,772	19	1,791	381	313	25,922	44,458	1.79 "	04.9	4,591 36	17.25 "	8.62 "	11,983	14,633
North-western, " 1852..	6,586	8,089	8,113	6,562	14,675	12,125	2,550	686	8	694	172	88	14,415	28,776	2.0 "	04.95	2,910 95	19.8 "	9.9 "	6,388	8,287
Totals.....	56,705	77,713	73,194	59,224	134,418	106,606	27,812	10,460	2,207	12,667	7,042	925	126,451	262,688	2.15 "	04.55	$21,462 96	15.96 "	7.98 "	62,067	72,351
	Ad'lts	Ad'lts																			
Boston Dispensary, A.D. 1796	2,805	5,882	8,687	5,649	14,336	7,094	7,242	..	..	..	218	283	6,764	34,685	2.5 "	05.	$3,888 08	0.27 "	12.5 "	..	..

We subjoin the following general statistics of the New York Dispensaries. Owing to the loss of its early records, those of the Boston Dispensary cannot be ascertained:—

Average number of years in which medical charity has been dispensed to the sick poor of New York by the dispensaries	29
Whole number of persons vaccinated in all the dispensaries since 1804	218,991
Whole number of persons who have received medicine, and medical, surgical, and vaccine service gratuitously since 1791	2,069,804
Aggregate amount of expenditures of the several dispensaries since 1791	$361,735 39
General average cost of medicine, and medical, surgical, and vaccine service to each dispensary patient since 1791	17.47 cents.
Average number of patients treated annually for the average twenty-nine years that the dispensaries have been organized and in operation	71,372
The New York Dispensary alone, in the sixty-nine years of its existence, has prescribed for	1,046,404

In Brooklyn there are three city dispensaries, not as yet systematized like those of New York, and having, up to the present time, no district physicians. There is also an eye and ear infirmary, at which persons suffering with diseases of these organs are prescribed for gratuitously, and a homœopathic dispensary.

Baltimore has two dispensaries or infirmaries; Cincinnati, Chicago, St. Louis, New Orleans, and Charleston, as well as some other smaller cities, one or more.

Besides these institutions, there are in connection with nearly all the medical schools in the large cities, *cliniques*, at which, at a given hour, once, twice, or thrice a week, patients are prescribed for gratuitously by the professors, in order to familiarize the students with the practical diagnosis of disease. Some of the medical schools have hospitals, with quite a number of free beds, for the same purpose.

We insert a table showing the annual amount of medical service rendered by the dispensaries of New York and Boston, and the small cost at which so large an amount of good is accomplished.

CHAPTER VI.

NURSERIES AND FOUNDLING HOSPITALS.

THERE has been a strong prejudice in this country against foundling hospitals, mainly undoubtedly the result of the mismanagement which formerly prevailed, and, to some extent, still prevails in some of the great European hospitals for foundlings. They have been stigmatized as offering a premium for licentiousness, and destroying the barriers against illegitimate births. On the other hand, it has been urged in their favor, that they tend to prevent infanticide and those crimes so prevalent in communities where no such institutions exist. After long deliberation, the public authorities of New York have decided in favor of a foundling hospital, which will be the first in this country.

Provision has been made for many years past for the care of the young children of criminals, and of paupers deceased, or incapable of taking care of them, in all our large cities. The usual method, if they are infants, is to put them out to nurse until they are three or four years of age, the city paying a dollar a week or thereabout to the nurse. In many cases, those who have thus taken charge of them were entirely unfit for the duty, and painful instances of cruelty and maltreatment of these unfortunate children have come to light. Close scrutiny is now exercised in regard to the character and position of those who apply for employment as nurses, and the abuses formerly prevalent checked. If the children survive the nursing period, they are placed in the public nursery or farm school, and there receive a good English education, and are then apprenticed or adopted in families in the country, or, in some instances, sent to sea.

The neglect and evil results which in many instances followed from the system pursued in these institutions, as well as the conviction that the infant children of virtuous parents, who were deprived of their parents' care by death or extreme poverty, were entitled to a tenderer watchfulness and supervision, has led in most of the large cities to the establishment of nurseries, infants' homes, and other institutions of a similar character, for children of this class. The "homes for the friendless," a class of institutions we have elsewhere described, have received very considerable numbers of these children, and after carefully examining them, have provided them with good homes, where they have been adopted by those who received them. There are also in New York, Boston, and Philadelphia, hospitals for the infants of legitimate birth. An institution much needed in all our large cities, and which has just been established in Boston, is the *crèche*, now very popular in most of the European cities. It is a large building, with fine, airy, well-ventilated rooms, fitted up with cradles, toys, and every thing necessary for the care and amusement of infants and young children, and provided with a sufficient number of amiable and intelligent nurses, where the poor mother, whose daily toil sustains her little flock, may leave them for the day, certain that they will be well cared for and receive wholesome food. For this care she pays a sum graduated to her ability.

CHAPTER VII.

HOMES AND ASYLUMS FOR THE [illegible] AND INFIRM.

FROM the care of children who have been bereft of a parent's tender love, to the [illegible]

vision for those whom the burden of years and infirmity has reduced to an almost childish feebleness, seems a natural transition. For this class, and especially for women who in the time of old age find themselves without those who can minister to their wants, and to whom the almshouse seems almost as terrible as the grave, the large-hearted charity of the philanthropic in most of our cities, has made liberal provision. New York has five institutions for this class, besides several relief societies intended mainly for them; Boston three or four, one of them largely endowed; Philadelphia four; Brooklyn two, one the Graham Home, nobly endowed by one of her citizens; Baltimore two; and the other larger cities one or two each. In Boston and Philadelphia there are also institutions for aged clergymen, merchants, and others. New York has an asylum for infirm seamen, the Sailor's Snug Harbor, located on Staten Island, and founded and amply endowed by the munificence of a retired sea captain, Robert R. Randall.

Provision has been made in most of the Northern cities for children, the aged and infirm, and the sick of the African race, in separate institutions, but with accommodations fully equal to those provided for whites.

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